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INTRODUCTION: FUTURE-ORIENTED FOSSIL ENERGY
Research Governance, Prior Predictions and Aging Archives for Government-Sanctioned Technological Fantasy

The history of carbon capture and storage (CCS) begins for me in a window-lined office in Columbia, Maryland, in 2010. A blond-haired, blue-eyed environmental scientist, now practicing as a government consultant, is sitting behind his desk in front of a window overlooking an anonymous corporate parking lot. Watched by framed pictures of his child and wife, we discuss how I intend to travel to Australia to make a career swerve into social science research. *Why Australia?* Because with all the mining they do, the Australians have substantially funded the research of carbon capture and storage technology, which I want to understand. *Ah*. He delicately pulls a CD off his bookshelves, which have many binders full of technical reports and government brochures and few or no books, and tells me I can keep it—I may need it for reference.

The CD's cover image is of a sparkling green forest inset with four square tiles like windowpanes. One is of an oil pump jack, another is of a female scientist bending over a microscope, with frosty gray, 1980s "big" hair. The other two are forgettable stock photos of an electric power station and a view of half the earth from space. The title is "First National Conference on Carbon Sequestration. U.S. Department of Energy, 2001."

Fascination with the possibility of technological climate preservation motivated the interest I held at that moment. As I imagined, determined scientific and technological experts were facing unprecedented social and political challenges making a poorly understood field of practice deliver its results for an unsympathetic public that persistently misinterpreted their work as cynical "greenwash." A graduate research project in social science, I believed, could throw light upon the more complex experiences of those experts in terms of responsibility and idealism while technologically preventing greenhouse pollution.

The CD made it into a pile in my own less orderly bookcase at home, along with paper records from the first informational interviews I conducted with CCS geologists and paper printouts from the somewhere between two and seven different “CCS project databases” that existed at that time. The disk and its data began their journey through time.

A decade later, I open the case and nervously scan the warning that the disc will only display its contents on Windows 95 or higher. But across the living room, my partner yells: “Windows has backwards compatibility.” By this, he means that newer versions of the Windows operating system are able to safely open files created for Windows systems of yesteryear. Yet I select the oldest hardware I own, with consequentially the oldest software upon it, to proceed. I download the files onto the only computer I had that would accept CDs, the “free computer” that I had asked for and been given by the IT department’s recycling program when I returned from fieldwork in 2018 without a computer to type upon or the means to buy one. My predilection, or perhaps socioeconomic requirement, to keep using old and recycled things, in that moment, ultimately preserved my access to an archive of the best and most futuristic promises of the U.S. Government from 2001.

The files are abstracts. A disclaimer states that the DOE does not guarantee the accuracy of the documents, nor did they intensively edit the content, although it looks flawless and authoritative: scientific paper after scientific paper, as presented nineteen years previously at an industrial and governmental event. At first glance, the types of for-profit companies who sent their scientists to present at the government-hosted meeting and the types of research paper topics and questions that were taken up appear the same as the ones I encountered in the greenhouse gas technologies conferences I attended between 2013 and 2018. Attendees hailed from chemical and industrial gasses companies, oil and coal mining companies, electric power technology and utility companies, universities, national laboratories, the national environmental agency, and ambiguously-named firms such as “Bek Associates” and “Thermo Power Corporation.” There is an oil lobbyist, an environmental NGO, and three people from the government contracting firm where I worked at the time I received the CD, perhaps assisting with meeting logistics or keeping up-to-date on clients’ social and intellectual needs.

However, differences lurk that become visible after my fieldwork and because of it. Most obviously, the CD cover art reflected what is now a lost experimental system (Rheinberger 1997): studies of the sequestration of carbon in soils and forests that the picture seems to evoke are now completely disconnected from the research or engineering community I accessed between 2013 and 2018. Namely, I attended six different carbon capture, utilization, and storage research conferences or strategy meetings across those five years, with no personal purpose except to meet people and hear presentations. I did not encounter a single soil sequestration researcher during that entire time. (Out of hundreds of conversations, I did encounter two people who sought to sequester carbon in building materials such as plaster wall panels, and one person who was inviting new collaborators to help study the carbon-sequestering properties of his constructed algae ponds.) Yet, if the green foliage is meant as just a symbol or an aspiration and not as a direct investigation area, then the aspiration persists. It persists where any student chooses to study “clean energy,” or when a consumer product advertises an icon of a better, fresher nature through technoscientific mediation. It scribbles hasty lines between hopes, problems, promises, and offerings.

Time and fieldwork have changed what I notice and assume. Upon receiving the CD in my colleague's office, I silently and immediately conceded that the government energy department would *of course* have access to and actively use the "best expertise possible" related to a topic—without even noticing that it was a concession. Yet now, I am inclined to ask: How did those participants actually get onto the "expert panel" who were allowed to give the government relevant advice, shaping the roster of who else was brought into the conversation as well as the next sets of thematic questions that would be taken up? Has that expert panel changed in the past ten (or twenty or thirty) years? And why is its visible gender and racial composition so infuriatingly predictable? How much was each paid to be there, and did the eligibility criteria for service include a firm prerequisite of having already made millions from energy technologies?

A decade earlier, I would have assumed that government preferences amongst modes of expertise and technology had taken place in some transcendental realm, where the best knowledge and the best judgment to select that knowledge reinforced one another like a snake eating its tail. A decade later, I would bring to the subject a suspicious, angry, and unsatisfied mind, not assuming that authority is knowledge-based, but instead that knowledge is authority's alibi. What should be interesting to know for readers more sympathetic to one of these vantage points rather than the other—as both are expected readers of this work—is that the ethnographic project was designed from the former, but produced the latter.

Inquiries

In this study, I am interested in the targets of care and responsibility that are institutionally cultivated, circulated, and advanced by practitioners of energy and environmental professionalism and negotiated in the daily practices of their work. This dissertation's purpose is to illuminate the conceptual, social, and historical factors producing a specific cultural ideology by which Australian carbon engineering can be and is known as a benevolent intervention,[1] or in other words, the factors producing an institutionally-mediated topology that conceptualizes these kinds of carbon engineering as a mode of care.[2]

The pathway towards anthropologies of institutions was opened by Emile Durkheim (1984 [1933], 1992) and Mary Douglas (1986), who each proposed that tendencies in ethical reasoning, as well as key metaphors for culturally-specific rationalities, can be located in human collectivities, such as professional groups in an advanced industrial society (Durkheim 1992). The implicit contrast is to perceive only individual humans—or "societies" or their concepts—holistically and abstractly as the basic subjects of social thought.[3] Emphasizing the disciplinarity of expert work—the institutions, including engineering fields, by which it is conducted and conceptualized—can contribute to the understanding of technological ethics because it proceeds from an assumption that social processes of formation (Downey 2008, 2012, 2015) that people

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[1] At the latest stages of writing (i.e., 2020), I began to freely label carbon capture, utilization, and storage research engineering as "carbon engineering." This not only bears witness to the likely source of the carbon in fossil fuels; but also the likely source of the personnel in petrochemical industries doing the work of managing it. In other words, "carbon engineering" is not an originary category built into the initial fieldwork design, but produced during the analysis.

[2] By "topology" I refer to the sense that a single geographic location is not the right place to find people with similar attitudes, values, and experiences in relation to an instance of technoscience. For example, Emily Martin refers to a "moral microclimate" among pharmaceutical industry employees (2006). My choice of the word "topology" is meant to foreground the possibility that two people who reunite at a professional conference from separate sides of Australia may have much more in common with each other ethically, politically, and in terms of conceptual reasoning and problem-solving approaches than either of them has with a third person working in the next building over. This analytical possibility has been raised by scholars such as Robert Merton (1973) and Ludwig Fleck (1986) regarding scientific, professional, and medical collectives.

[3] Methodologically, to suggest that individual persons are not the privileged locus of all of the thinking and feeling underway in my fieldsites is especially compelling as a counterweight to tendencies in anthropological thought to drift away from emphasizing "the social" as an important conceptual underpinning to analysis (Kapferer 2004, 2009).

undergo while joining a profession have consequences for the particular ethics adopted and promulgated by particular social groups. It explores the possibility already raised through ethnographies of disciplinary ethics (Lederman 2004, 2006, 2007) that ethics can be situated in disciplines, i.e., institutions, while simultaneously asking what, if anything, coheres a discipline if it is neither one unified field of knowledge nor one unified field of practice.[4]

Assuming that Australian scientific and technological institutions have provided the symbolic and conceptual conditions—the groundings for rationality and ethics—that allowed carbon engineering research to flourish, this dissertation will describe Australia's institutional situation of engineering ethics (whether or not it goes by that name), and what modifications it has grown up through, especially since 1980, as accessed through primary archives and the lived memory of ethnographic research participants.

Empirically, CCS maintains a high profile, continuing to receive substantial government and private investment even though the technology is not in the process of becoming widely used. Over my ten-year investigatory span, there have been no changes to the fantasy structure (Marshall 2016) of what in the best possible universe CCS could achieve. But there *have* been extensive attempts to realize those promises and a growing gap between the people who encounter the promises in isolation/at face value and the people who encounter the promises contextualized by historical and economic information. What is at stake for CCS's observers is

[4] Williams (2002) argues for the existence of an "expansive disintegration" of the engineering disciplines in the United States: a greater number of people and activities are laying claim to the term, putting its coherence at risk. "Engineering is ending only in the sense that 'nature' is ending: as a distinct and separate realm" (31). On a more concrete level, CCS as a field and engineering projects as they are practiced are "multidisciplinary" in their teams of staff, e.g.: "Nobody has training related to a ZeroGen project. The training is about the science and research of gasification."

whether and how speculation about a desirable possibility should be socially burdened by historical memories of prior ways that this same speculative desire has failed to become realized.

Meanwhile, the professional and personal location from which CCS can be observed—"energy engineering" as a professional and personal identity and line of work—has changed, as has been blandly asserted by so many Australians. One point of reference for this change is the phenomenal expansion of rooftop solar generation across private households during the 2000s, changing the need for and direction of electricity flows and the style and strength of needed infrastructure. A further point is the creation of new political contests around climate change policy, to which "engineering" as climate change response can be drawn upon as a symbolic contrast with the supposedly anti-business and irrationally-emotional demands of climate-concerned publics. The meaning of engineering cannot help but be changed as the nature and scope of human damage to the biosphere becomes broadly evident, and the practice of engineering cannot help but be changed as its governance becomes neoliberal and the infrastructure it intervenes upon becomes differently scaled, composed, and owned.

In ethnographically contextualizing the persistence of Australian (and global) CCS investments amidst engineering institutionalities, I ask: How do the disciplinary and institutional norms of engineering contribute to that continuation? What are the specific elements from which carbon engineering's material and epistemic creativity and its networks of discourse and advocacy (Fortun 2001, Kittler 1990, Riles 2000) have accreted? What are the modes of knowledge, ethics, and social authority within Australian society associated with Australian science and technology, of which the CCS research industry is an instance? By investigating the reasoning by which CCS is known and presented as a responsible technological intervention on a warming planet, this study addresses how advancing the establishment of contested technology can be seen as ethical work that people would desire to conduct or support despite recent independent scientists' conclusions that CCS cannot fulfill the promises attributed to it (e.g., Page et al 2009, Jacobsen 2019, Hansson 2012, Tsouris et al 2010). Ultimately, this study contemplates whether the proliferating sociopolitical lines of awareness and intervention related to climate change has put any stress upon the traditions of practice within the fields of expert work from which CCS's workforce has derived, and if so, how and where these stresses have been felt.

Research Process

I began keeping ethnographic notebooks in 2013 in order to explore analytical possibilities for contextualizing the CCS research industry within the professional and disciplinary norms of "energy engineering." Although these two distinct objects of study could be interpreted as requiring two separate ethnographic projects, forcing them to intersect in a single investigation lays bare the many gaps, disconnections, and silences that otherwise go unnoticed within an expansive conceptual and empirical terrain that supposedly contains both "engineering" as a specific, institutionalized bundling of meanings and persons, and carbon (or energy)[5] engineering as a knowledge and practice area. What was exposed by crashing multiple ethnographic inquiries together into one were silences, omissions, and absences—such as the omission of any concept of "bad technology" from engineering ethics codes. Also exposed was the mutual inability of CCS industry employees and electric grid employees to discuss the

[5] An energy expert discussing his career background with me in June 2018 explained: "I migrated from carbon to energy. In Australia, we don't talk about carbon, we talk about energy."

technological properties of each other's work, despite representations of CCS as the electric grid's necessary stabilizer. This dissertation's research data contains a parade of silences, refusals, and gaps. Reading across these absences, the disunity between one particular engineering field's practices and social imaginaries and more general gatekeeper institutions' practices and imaginaries is unexpected but informative.[6]

Arguably, ethnography in general has synthetic tendencies insofar as it can see within some entity "imploded" traces of the worlds that have made it what it particularly is (Dumit 2014). This theory of ethnography normalizes an ethnographic investigation of two abstractions intersecting. Not only does carbon engineering potentially exemplify "engineering" generally, but the two also share substance with each other in moments where carbon engineers are granted authority on the back of engineering's socio-cultural weight, and in later and more subtle moments where what is being said and done about carbon in "engineering's" name causes the concept to take on new social and conceptual specificities.

My multi-sited dissertation fieldwork centered upon two main empirical cases—a carbon capture and storage research management company and an engineering professional association. This is supplemented by attendance at public events and a review of printed material regarding technology, expert education or professionalism, energy, carbon, and climate. This was a compromise between an original plan and the affordances of my actual fieldwork relationships. At the time of proposing my research, I wanted to divide my time four ways: a phase with a

[6] By gatekeeper institutions, I refer to the nationally-centralized authority that accredits engineering degree programs, certifies individual practitioners as aligning to the expected knowledge and practice standards of their field, and advises on engineering migration, as well as the schools themselves.

carbon dioxide engineering research company, a phase with recruiters who brokered between prospective energy engineers and the workplaces seeking to hire them, a phase of archival study, and lastly, intermittent time spent at the engineering professional association to observe the formalities and interviews by which a centralized certification of one's engineering professionalism could be obtained. The final three were not able to be carried out due to the unwillingness of recruiters, engineering association staff, and the certification process's overseers[7]. These cancelled empirical trajectories were substituted with time at public events related to professional certification, energy and climate, and professionalization, as well as time in individual social relationships with people who had taken their own trajectories through these three exclusive, excluding, and ultimately excluded sites.

Throughout this project, I have strongly believed that the boundaries of empirical investigation must not be isomorphic with those of any single institution. I allowed my preliminary fieldwork at a coal seam gas company to inform my questions and perspectives brought to later fieldwork in the carbon capture and storage research industry because, as I wrote in dissertation research notebook 11, "People move around. Ideas move around. This is all knotted together by literature review." By that, I expressed that my project's coherence has been sustained, not by supposed empirical edges of a preconceived worldly object, but instead by the boundaries of a theoretical inquiry and its precedents.

(1) I held an internship at the carbon capture and storage research management company and attended research and practitioner conferences, research review and strategy meetings,

[7] The nature and substance of these refusals will be addressed in conceptually-related subsections of the dissertation body chapters. The experience of these refusals, combined with the contents of the information that could be gleaned despite them, contributed to my critical personal transformation.

coffees and lunches with workers, and an in-person university class on fundamentals of geological carbon dioxide capture and storage. Much of what this internship actually created was connections to internal and external interviewees and forums where they could be met. Interviewees for this project included clean coal and CCS scientists, experts, advocates, and rural community members affected by a proposed CCS project in the waters offshore of their local beach. Also interviewed were trade unionists founding their solidarity on shared technological expertise regarding electrical energy; activists and mobilized community members seeking to prevent climate change and pursue social justice; renewable energy and electricity network industrialists; a handful of government workers; and engineering students, professors, association leaders, and administrators.

(2) At the engineering professional association, which is a unified national body for what it considers all fields of engineering, I attended professional events, meetings, and conferences at the Victoria, Canberra, and Sydney offices. I explored archival records of its publication patterns, institutional restructuring, historical ethical codes from 1916 to the present, and historical policy advice regarding energy, climate, and engineering workforce development. Ultimately most of the events and meetings that ethnographically informed about this institution were at least semi-public, or one that its members could pay a simple entry fare to attend.[8]

My archival research sites were the Australian Academy of Technology and Engineering and the State Library of Victoria, as well as the basements of two libraries at the University of Chicago for historical professional association papers. Analytical documents regarding CCS

[8] In this dissertation, it is referred to interchangeably as “the institution,” “the [A]ssociation,” “the engineering professional association,” or “the national authority” in order not to trespass upon its actually or potentially trademarked identifiers or proper name.

technology and engineering workforce and educational concerns, such as "submissions to government," were also collected and reviewed. These included media and journalist accounts; industrial "situation reports" that a subcontracted worker in another state compiled each week for the carbon engineering research management company; three public-facing magazines addressing energy and climate technology; the association's technical journal and magazine; and an unruly collection of presentations, reports, and advertisements from energy and climate researchers, activists, and industrialists dating from the 1960s until 2018 (with the greatest density of sources dating between 2006 and 2018). My methods for contexualizing meanings and values of carbon/energy engineering in Eastern Australia include subscribing to a central-Queensland-based activist newsletter with weekly mining-related news and attending public industrial site tours of an aluminum smelter and several electric power stations. My views are also shaped by preliminary research at an oil and gas company office site.

Public events regarding energy and climate were selected for attendance in Eastern Australian cities and country towns, especially Brisbane and vicinity, from 2013–16, and Melbourne and vicinity from 2016–18, on the basis of whether they would illuminate how Australians configure and conceptualize energy, environment, expertise, and responsibility. These events included lectures, seminars, and webinars on research results from PhD students, consultants, industrialists, and visiting scholars; a free online EdEx course regarding carbon capture and storage; a class on "introduction to the Australian energy system" convened for and by activist citizens; three "open house" days at engineering schools seeking to recruit new undergraduate students to enroll; a student "hackathon" called "The Energy Hack" that I nearly walked out of due to its almost intolerably non-inclusive social environment; two Central

Queensland music festivals with strong environmental themes; book launches and documentary screenings; and two industrial site visits to carbon capture and storage facilities, one alongside professionals and a second alongside students.

Although the term “energy engineer” is my own term, in practice I spoke to power engineers, electrical engineers, carbon capture and storage scientists and engineers, coal seam gas mining engineers, professors of “energy” generally, chemical engineers, geologists, a combustion scientist appointed in an engineering department, and many more. Participants were asked how they specialized in taking their type of work; how they decided whether to categorize CCS as “green energy technology” or “fossil energy technology” or as something else; key historical moments they have lived through in their professional fields; and what aspirations they have had for their own work in energy engineering, no matter how they defined and bounded “engineering,” which varied by person.

The resulting data, profoundly multi-sited and multi-modal, were analyzed between 2018 and 2020 to study for participant’s concepts of what engineers and engineering are and can be and how engineering does or does not have efficacy to transform social relationships with energy and climate. I was interested in the targets of care and responsibility that are institutionally allowed by these industries, circulated and advanced by practitioners acting as energy and environmental professionals, and negotiated in the actual practices of their work.

Arguments

This dissertation argues that rather than being a sui generis entity, entangling novel ethical concepts and concerns, the CCS research community presents a logical continuation of how professional ethics, applied technological research, and the Australian state’s relationship with engineering expertise have unfolded over time. It demonstrates the informative gaps and disconnections that emerge from attempting to study the undeniably multinational CCS research industry in entanglement with Australian engineering institutions and their ethical practices generally. Chapters contextualize beyond the walls of CCS field sites and offices, each presenting an anatomy of one element of carbon engineering's institutional home.

To the ultimate question of whether social awareness of climate change is changing energy engineering in Australia, this dissertation answers in the negative: it is not the socio-political interest in climate, but instead the structure of the businesses and certification-management regimes attempting to practically capture and enmesh "responsibility" into how carbon and energy engineering is done that matters most effectively for how responsibility is negotiated in practice. Put differently, many interlocutors appear to be infusing their carbon engineering (or adjacent) practices not with their "personal beliefs" as individual Australians, but instead with some version of the institutionally-mediated forms of ambient social belief formalized into regimented and legitimated types of practice and approach.[9] To the extent that Australian concepts of expertise, responsibility, and authority applicable to CCS technology have undergone any recent reconfigurations, those appear more causally related to the way businesses, certification regimes, and other governance functions institutionally imagine and locate responsibility than in how individual practitioners selling their time and services imagine and locate it. Here are the arguments that cross all chapters:

Regarding responsibility and value: The CCS industry arises amid conceptual confusion between a precise and an imprecise meaning of sustainability. The first is the continuity of

[9] "Professional ethics" is one, "engineering standards" or protocols/operating procedures are others. Institutional regimentations of responsible practice are addressed throughout the dissertation in the moments in which interlocutors raise them for consideration.

industrial businesses, and the second is about human and environmental survival. CCS continues to thrive because it is able to present itself as a means towards either of these ends—or both—depending on the particular conversation. Indeed, discussions of CCS produce publics by making explicit these multiple possible survivals and asserting that survival here is zero sum—one of them may be gained only at the expense of the other. Even when it is presented as a means towards one of these continuities alone, the social fact that other publics care about the other continuity serves to make CCS seem “more promising” because their caring engagement seems able to be harnessed: in an advanced capitalist moment, the fact that something seems potentially interesting to a large audience—whether or not that interest is grounded in actually-existing efficacies other than to attract interest—makes that thing worthy of investment.

Regarding value and knowledge: Industrial knowledge began to flow into CCS projects under conditions in which climate change response was conceptualized as a burden. Carbon storage spaces were presented as a cost to be paid for, and the emerging research industry circulated advocacy about emission reductions implying that by connecting CCS technologies to other industries, it could decrease their environmental footprint. However, as the projects continued, conditions have changed: knowledge began to flow back out of the CCS projects into their industrial sponsors as research findings and “in-kind” intellectual property.

Simultaneously, climate change response has transformed in meaning from a burden to an opportunity. Storage spaces have become conceptualized as assets rather than costs (e.g., National Energy Technology Laboratory and the Great Plains Institute 2017, Bongers et al. 2017), and while the advocacy about CCS-enabled emissions reductions continues, industrial uses for CCS in practice come to include enabling newly-built extractive infrastructures to emerge unscathed by the social contestation they would otherwise face, regarding climate dangers. Indeed, newly-built extractive infrastructures such as a hydrogen-from-coal project and a gas terminal atop a former nature preserve can be justified in the name of reducing emissions. Despite the fact that emissions reduction can be presented as a cost to businesses, one person's cost is another person's income: the agents who sell their time towards lifting burdens have found that in practice, "climate change is a growth industry." If states can accept liability for long-term consequences and can subsidize the infrastructure and energy costs to inject carbon underground, storage spaces can become assets through which payments can change hands in "economies of repair" (Fairhead et al. 2012). Although advocacy portrays CCS as a way to reduce emissions, the practical result of invoking CCS can include the enablement of financing and narrative justification for new construction projects or for the continued use of old industrial plants longer than their designers intended.

Regarding knowledge and authority: The multiplicity of expert knowledges invoked to create a CCS project increases the burdens of producing an authoritative critique beyond the means of would-be critics. First, experts in energy engineering decline to critique projects they are not employed by, amid cultural assumptions that *having received investment* demonstrates a project's intrinsic rationality according to the sum of multiple knowledges privately accessible to investors.[10] This is witnessed by the countless silences and hesitations among energy experts

[10] Whether or not a project is "rational" is to some extent an actors' question and category that their choices of words has forced into the ethnographic record. However, it is a defensible word choice for this analysis because an engineering project *in the world* (essentially, infrastructure-under-construction) is something beyond the scope of concepts such as scientific validity because it comprises things like labor schedules, materials and parts, manufacturing regimes, etc.—all of which expand beyond the notion of truth or inaccuracy, or even the notions of knowledge or information conceptually associated with "science." Rationality or reasonableness is a term referring to an appropriate course of action, and an engineering project can be considered a course of action taken by its workers and funders; hence the term has entered this ethnography through ethnographic engagement with them.

when asked to discuss whether they considered CCS to be promising or not—on tape—and by the explicit reasonings they gave for this demurral. In other words, since prior “due diligence” by investors is assumed, a project on the public stage becomes known as rational because it has already been deemed investible. Second, CCS industrialists rhetorically shift the basis of the intellectual authority underpinning their claims based on the epistemic perspective from which a critique directed towards their industry emerges. For example, if told that “storage space is unavailable for all that carbon dioxide”—a critique based on the physics of volumetric compression and geological spatiality—then industrialists can say that “source-sink matching” created through business expertise can alleviate that concern, and even email me a prior researched report addressing how it can be done. Logistics, not physics, is made to speak to the question. In another example, if told that one of their projects has failed because it did not deliver electricity, they can respond that it has succeeded because it delivered academic knowledge; researchers, not the state electricity grid, can claim it as their success. Third, there is a concrete and fundamental multiplicity of knowledges at work within the daily research practices: capture and storage research are intellectually independent and do not peer-review each other, but are bridged instead by managerial experts who speak about the results of the fusion between the two types of research. As a consequence of these three developments, neither any one discontinued project nor the assessments made via any one expert modality—physical science in capture or storage, engineering skillfulness in capture or storage, or business acumen of any kind—can effectively discredit the CCS research industry’s future potential.

The particular way that CCS finds itself making arguments to government and other funders exemplifies the social status of engineering knowledge after a massive privatization and decentralization of engineering businesses in recent Australian history. The movement of engineers out of government businesses and into competing alternative contractors and subcontractors meant transformations in how engineering research, engineering early-career education, and engineering construction and maintenance could be done. As provocatively phrased by a recent retiree, “government lost the ability to assess its own projects.” Once the location of expert engineering knowledge becomes extramural from the authority and budget to build infrastructure projects, the question of what energy and research infrastructures are worth investing in becomes especially politicized and financialized, subject to advocacy from interests capable of hiring researchers. Research, analysis, and advocacy develop blurred borders. The question of whether intellectual “independence” can be adequately located within a “third party” becomes particularly fraught when experts perceive themselves as hired to solve a company’s problem, or “box” (see Chapter 4), not a social or environmental problem generally.

Regarding authority and responsibility: CCS continues to receive support in part because the energy engineering experts who could, if they so desired, define it as “not promising” in authoritative public statements are inhibited from doing so by the concepts they hold of personal agency, knowledge and knowability, and professional etiquette within engineering fields. Regarding knowability, it is assumed that only a project’s own team will have the most accurate information regarding a project’s feasibility and costs. Regarding etiquette, in Australia, formally codified engineering ethics have been a means of shoring up a boundary between certified “engineers” and other materially and technologically skillful people. Consequentially, speaking for or about “environment” or “community” cannot come to mean a foundational critique of peers’ practices, because it already been configured as an additional mode of certifiable knowledge and means to gain social distinction. Under the influence of this type of codified ethics, engineering professional association activities regarding community, environment, and responsible technology can become a means to dampen rather than to amplify critiques.

Chapter Structure

Chapter 1, Background, studies historical inheritances for the carbon research industry observed through fieldwork in eastern Australian cities. It presents the dissertation project's conceptual approach to CCS is, how it is industrially located, how it has been politically located in global climate change mitigation projects, and how it is situated within Australian anxieties about energy, climate change, policies, and vulnerabilities. In doing so, it seeks to answer what knowledge, personnel, and socio-political expectations have formed the CCS research industry. To understand this, it is important to understand two sub-stories: how "social sciences of CCS" have been pursued, and also, Australia's historical relocation of "energy expertise" immediately preceding CCS's flourishing. Overall, the chapter seeks to establish how Australian carbon engineering has come into existence, against which sociopolitical backgrounds.

Chapter 2, Industrial Metonymy, traces the contours of financially-consequential public rhetoric that take environmental technoscience as their point of reference. It describes the making of the Australian Clean Energy Finance Corporation's 2017 CCS inclusion policy, which delineates what kind of investments are considered clean energy and thus worthy of receiving funding. It raises the question of how industrial actors gain and maintain the social authority to speak for not only the properties of a technological "fix," but also the qualities and properties of what counts as a problem. This chapter argues that the problem of climate change is rhetorically shrunk to a problem of solely "carbon" and is then able to be met by coal technologies. In parallel, coal technologies are rhetorically set as "clean" by scaling partial relationships into more expansive ones. Meanwhile, notions of parity, equality, and "technology neutrality" are advanced in policy conversations. Through these forms of rhetoric, fantasies of technology (Marshall 2016) are sustained. In this critical negotiation, knowledge, ethics, and political authority within or around the practices and sites of Australian science and technology are rendered ethnographically visible. A consensus fusing scientific, industrial, and governmental authority about how carbon dioxide is the core problem of climate change—not lifestyles or economic growth or any other pollutants—comes into being.

Chapter 3, Codified Ethics, situates “engineering ethics” within a historical class politics of expertise. It argues that in Australia, ethics codes and "professionalism" are a newer alternative to prior modes of affinity among expert technological workers, and that these ethics codes are entangled with an ongoing social process to restrict the wrong people from working as engineers. It finds that engineers have been differentiated from skilled tradespeople not on the basis of the objects or industries they work with, but on their level of education and their actual or potential participation in professionalizing activities—ultimately arguing that the process of codifying practitioner ethics is related to using formal education and credentials as a basis for inclusion in, or exclusion from, "engineering."

Chapter 4, The Research Engineer, ethnographically describes research engineers and other professionals who sell expert services, in order to ask what challenges the CCS research industry faces in binding itself to similar and related industries, what standards of excellence its practitioners cultivate, and what the key experienced tensions of their practice are. Continuing the histories that Chapter 1 began to sketch, it raises the possibility that large-scale social decisions about the role of engineers have been made in ways that have consequences for the social figure engineers now are. Today’s conditions of engineering thinking, working, and ethical reasoning are explored through one person’s concept of “the box,” ultimately lending insight into how members of the CCS community can sustainably hold a theory of their own actions as moral and appropriate—if not by adjusting their work, instead by adjusting their hopes.

This dissertation argues that through the institutional conditions of their work and the preconditions of their rationality, energy engineering professionals have been invited to lose the specific socio-ethical awareness that would tell them that aspects of the carbon research industry deserve critique. Or, through professional etiquette, they have decided not to voice a public critique, even if they have an awareness that something is worth critiquing. While the energy and climate activists and experts I encountered who had the will to critique CCS technologies were not attributed the authority to do so. In contrast, the engineering experts I met who would be attributed the authority to critique CCS technologies in ways Australians would consider evidence-based did not have the will to do so.

In a public talk I attended, Dr. Kari Dahlgren, an anthropologist who studies Australian mining communities, spoke of her ethnographic experience inland and more remotely, and crystalized her experience in the following casual remark, that nevertheless frames possibilities this dissertation explores: “All of the hydrologists work for the industries; you can’t get ahold of them.”

CHAPTER 1: BACKGROUND
<u>Emergence of CCS, and Its Relationship to Energy and Mining Economies and Engineering as a Professional Field of Action</u>

This chapter highlights ways in which Australian CCS shares an inheritance of personnel, sponsorship, and technological knowledge from common ancestral circumstances that produced today's Australian energy industries. Two sub-stories are relevant: first, of how the social location of much energy expertise in Australia has moved dramatically since the mid-1980s, providing grounds for reconfiguring the practice of expert ethics; and secondly, how "social sciences of CCS" have been pursued externally to this dissertation research. The institutional circumstances in which Australian CCS research is carried out are co-constructed (Jasanoff 2004) with these two histories. By looking at the changing location of energy expertise, and also the relationship that social sciences have had with technological sciences of CCS, we can better understand how Australian CCS has been shaped by its situation in Australia amid particular theories and practices of responsible engineering.

What is CCS?

"CCS" is the acronym for "carbon capture and storage." It refers to a promissory, virtual representation of climate-change-preventing technology, the effects of which include redirecting flows of financial investment and keeping carbon-intensive industrial sites operational amidst social challenges to them. An industrial environment that includes a CCS concept can be imagined as emitting carbon dioxide to the atmosphere at a reduced rate than would otherwise have happened. The official, technologically-oriented definition of CCS varies by year and speaker, but an exemplary definition for most of the years that funding has been available has been:

> CCS is a family of techniques that trap carbon dioxide (CO2) from "point sources" such as electric power plants, compress it into a liquid, and transport it to a suitable geological site for injection underground, where it is intended to reside permanently and therefore avoid contributing to anthropogenic climate change. (European Commission 2014)

In summary then: a set of capture or trapping techniques, a set of transportation strategies, and a set of disposal ("storage") strategies. From the beginnings of the post-2005 timeframe that the work of writing public-facing reports has been financially supported, it has been common to discuss "types of CCS" by referring to types of capture technique and industry to be decarbonized, not types of storage or transportation. These commonly reported capture "types" are "precombustion technology," "post-combustion technology," and "oxyfuel combustion" (GCCSI 2015)[1]. Transportation usually means a pipeline network, and storage or "sequestration" can mean burial within "depleted oil or gas fields, rocks containing unpotable saline water formations or incidental storage during enhanced oil recovery" (GCCSI 2015). Storage can also mean making commodities, such as concrete wallboards or farmed algaes (GCCSI 2015).

The full conceptual panorama of these "CCS types" above is not well-aligned with the actually-existing range of projects now practiced. For example, as mentioned in the introduction, work on algae farming is extraordinarily rare, whereas work on or in oil fields appears more frequent. I therefore taxonomize the "types" with some hesitation, cognizant that re-mapping the entire global collectivity of speculative and material activities is outside of my scope, yet aware that by neglecting to re-map it, I am propagating forms of conceptual work my project disagrees

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[1] During my core fieldwork of 2016-2017, both the pre-combustion capture and oxyfuel combustion research trajectories appeared relatively less active, and "gas separations," sub-surface monitoring technologies, and post-combustion capture topics appeared relatively more active. Although the caveat must be appended that merely by observing at one research organization I cannot expect to have comprehended "the shape of the field," this footnote is still made in order to convey that the public-facing taxonomy may by 2015 have become out-of-step with the in-practice taxonomy of current project types and funding availabilities.

with—such as the description of industrial sites by reference to their most glowing aspirations alone, and not their observable practices and post-hoc outcomes.

Many or most actually-existing CCS projects are interwoven with oil and gas businesses; either because their "capture" entails the separation of naturally-existing CO_2 from naturally-existing methane destined for sale as natural gas, or because their "storage" creates the financial benefit of an "enhanced oil recovery" in which placing carbon into an underground region assists in driving oil out of that same region. Nevertheless, substantial conceptual and representational work is done, such as through the publication of "energy technology" reports, fliers, and strategy documents, to make CCS appear related to low-carbon electricity generation. As of 2020, few projects have succeeded in building CCS concepts into electric power industrial sites. Yet as Chapter 2 describes, contestation surrounds what extent of the technology's use (in time, in space, and in rate of and kind of pollution reduction, across an industrial site) should be considered definitional of "success."

This dissertation's definition of CCS as a promissory, virtual representation is grounded upon two known social-scientific concepts: first, "performative speech," and second, ideology in the sense defined by Althusser: something that serves to reproduce the conditions of industrial production—specifically the social relationships that are necessary for industrial continuity—and can do so because it "represents the imaginary relationship of individuals to their real conditions of existence" (2008[1973]:36). The term "imaginary relationship" conveys the important point that the 'otherwise' and the 'reduction' in the phrase 'at a reduced rate than would otherwise have happened' are conceptual experiences, semiotically-mediated (Gal and Irvine 2019). By citing ideology, via Althusser, to define CCS, I raise the possibility that not only do CCS scientists and engineers continuously assess the socio-political embeddedness of their professional work, but also that they do so in ways infused by their imagined social and industrial circumstances: in a phrase, the “sociotechnical imaginaries” (Jasanoff and Kim 2015) made available to them by virtue of their specific national and geographical situatedness. Jasanoff and Kim define these as “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (2015:4). Sociotechnical imaginaries exist within scientists’ and engineers’ apprehensions of what CCS is, what sort of climate-related efficacies it has, and whether and how CCS work is “responsible.” They are ideological in nature, meaning that these are inflected not only by the disciplinarity of someone’s expertise, but also by their social circumstances as classed, racialized, and gendered professionals conceptualizing their own location in a multi-institutional ecology undergoing social critique.

The possibility of analyzing “clean energy” and its associated concepts and judgments as ideological discourses emerged for me in conversation with the engineering studies scholar Greg Adamson. Although he did not use the term, he pointed out that if engineering-intensive businesses can be presented as “green” to their employees, then those companies experience a “real HR [human resources] benefit”: they find that potential employees will even more intensively compete to become part of a workplace they can understand as improving the environment. Even for members of a scientific and technological workforce, strong capacities exist to create an imaginary of the relationship between one’s own work and one’s sociopolitical and industrial conditions of existence[2], as both Jasanoff and Kim as well as Althusser would suggest.

Not only does this dissertation define CCS as an ideological term, but it also presents it as an instance of "performative" speech and conceptual assembly. As defined in Callon's article "What Does it Mean to Say that Economics is Performative," "A discourse is indeed performative [. . .] if it contributes to the construction of the reality that it describes" (2006:7). Callon asks what "contribute to" means and he finds an answer in the notion of "pragmatics" in the study of language. Pragmatics, instantiated through the work of J.L. Austin, raises the point that some statements act upon reality rather than reflecting or representing it. CCS is defined in this dissertation as a promissory, virtual representation in order to reinforce that as "CCS technology" becomes more widely spoken about, it becomes more socially real. That is to say that the consequences of such speech (and conceptual assembly, such as the drawing-together of "fact sheets" that purportedly describe a shared technological "type," making them be "the same thing" despite their dispersal across multiple continents and industries) reverberate and can be studied in isolation from any other expert activity. For example, take the sentence "top scientific minds are studying new CCS configurations." To interpret it as a descriptive utterance means to accept that the speaker pronouncing the sentence can accurately describe who counts as a top scientific mind or what counts as a new scientific configuration. Taking the sentence as descriptive means assuming that the speaker has the authority and methodological judgment to determine scientific excellence or novelty. Yet, shifting to interpret the same sentence as a performative utterance means attending to the consequences—which can be called the

[2] Please refer to the Epilogue's subsection named "Normative Holism" for a concluding discussion that integrates this dissertation's data with Downey (2012)'s term for what could be called ideologies, or sociotechnical imaginaries, of engineering responsibility.

pragmatics or the illocutionary effects—of that statement. These effects are that CCS becomes more socially real, more prestigious, and more promising due to the mere fact of the enunciation.

This dissertation defines CCS partially by reference to its performativity and its ideological imbrications, rather than by reference to any actually-existing technological devices. It is important that the references to technological systems not displace attention from the appraising, evaluating narratives that they continuously ground, for example that 16 (or 22) "large scale integrated CCS projects" are "in operation or under construction" (GCCSI 2015). Mere declaration of a certain number of existing projects exists may sound flatly descriptive, but this dissertation illuminates it as an appraisal, evaluation, or judgment—a result from conceptual assembly work—and one that performs consequences. Specifically, by forwarding a concept called "industrial metonymy" that describes the dynamics of forgetting that can underpin claims to status as "clean energy technology." Chapter 2 loosens the relationship between the label of "CCS project" and an installation's status as a carbon capturing and sequestering endeavor.[3] CCS's ability to bundle together different technological types and qualities, and the consequential nature of this conceptual work (in terms of its influence upon sociotechnical imaginaries, ideologies, and discursive performances) deserves foreshadowing alongside this dissertation's explications of CCS technologies in order to illuminate the partiality and

[3] The chapter ultimately evaluates Australian CCS as a response to the threat of decarbonization (felt by specific social agents), experienced and presented as a response to the threat of climate change (felt by a more general set of entities). "**Decarbonization threat**" is defined in Chapter 2 as follows: Insofar as it rearranges what counts as wealth and what financial opportunities may be realized, "decarbonization" as a social process may be experienced as a threat by any person or institution who has been succeeding in a carbon-intensive economy. CCS can serve as a response to this decarbonization threat, although rhetorically presented as a response to the threat of carbon itself. Through technological installation or its potential, CCS can absorb sociopolitical critiques of environmental harm without allowing them to damage existing infrastructure's financial value.

ideological engagement of otherwise concrete-seeming declarations such as that CCS technologies are “here” and “real,” “today.”

How Has CCS Emerged as Climate Mitigation Technology in Relation To Energy and Mining Economies?

Carbon engineering’s “past” is readily constructed as existing in a “technological zone” (Barry 2006) that is relatively less coextensive with national boundaries.[4] Therefore, to situate CCS in history in a way that respects technological knowledge, this section will adopt a frame of reference larger than Australia, and larger than current terminology.

Technologically, carbon capture and carbon storage began as separate projects, neither having any conceptual relationship with climate change prevention, and the technologies preceded the “CCS” name. The US called a “first national congress on carbon sequestration” in 2001, and the term CCS first appeared in European Union policy documents in 2005 (Arranz 2015). Soon after this conceptual invention, and the retroactive enrollment of 1990s gas processing activities as its exemplars, huge financial investments were being made by governments into research consortia[5].

Regarding the ancestry of carbon storage: practices appeared in oil and gas industries that by 2005, would be given the name “CCS” (Narita 2012). From the 1960s to the 1990s, petrochemical experts built background knowledge in subsurface fluid management that would later be applied to mobilizing and storing carbon dioxide far below the earth’s surface. The

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[4] “[A] space within which differences between technological practices, procedures, and forms have been reduced, and common standards have been established” (Barry 2006). Compare also Downey and Dumit on “citadel spaces” (1997).

[5] These are typically consortia of oil and coal mining companies, electric power technology and utility companies, universities, national laboratories, and different branches of state and federal governments.

"1990s demonstration projects" emerged in the natural gas industry that are still commonly presented as instances of successful CCS.[6] The operators of the "Sleipner" project established in 1996 off the coast of Norway retrieved natural gas from beneath the seabed that was already mixed with CO2, and in order to sell that natural gas to customers, it needed to install separation equipment to clean the CO2 out of it before it could be a viable, saleable fuel.[7] Operators in Norway had to contend with the fact that any CO2 emissions to the atmosphere would have been taxed (Evar, Armeni, and Scott 2012), and they would either need to pay that tax or instead pay for the energy and equipment to deal with the CO2 in another way than by pouring it into the atmosphere. Sleipner is a type of facility called a gas processing facility, and many of the other early and major CCS projects, such as In Salah in Algeria, Snøvit, and Weyburn-Midale, could also be categorized this way. These sites are part of oil and gas mining projects, much more so than they are part of electricity industries.[8]

Regarding the ancestry of carbon capture: designers of chemical plants had done decades of work on technologies such as ways to clean natural gas that emerged from the underground mixed with CO2 before that gas could be sold; ways to produce oxygen-rich environments to burn carbon fuels; and cryogenic technologies for compressing carbon dioxide. Air separation and compression technologies are material precursors for what are now called the "capture side" of CCS. In the 1930s, technical experts learned how to "sweeten" methane, also known as natural gas, by separating the carbon dioxide that emerged from the ground along with it and

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[6] Natural gas is methane; either term may be used in what follows.

[7] See van Egmond and Hekkert (2012: s156) for an explanation of how natural gas purification is a widespread need, although "storage purposes" are recent.

[8] This detail will become important where CCS's efficacy is contested, as will be seen in the chapter "Industrial Metonymy." Some speakers subscribe to the logic that "gas separations" projects are considered a "success" applicable across many industries and applications, but some speakers will not.

releasing the CO_2 to the atmosphere (Bottoms 1930). Alternative fates for that CO_2 became available, thereby potentially linking practices of capture to practices of “storage”: in 1972, naturally-occurring CO_2 was forced into the ground as a pressurized fluid to obtain more oil from a Texas oilfield that was in the process of running out of oil (Donaldson et al. 1989).

This historical evidence of technical practices being used many decades before the first demonstration projects that were explicitly named “CCS” means that neither the separation (“capture”) of CO_2 from other gasses, nor the burial or injection (“storage”) of CO_2 beneath the earth is unambiguously innovative, novel, or cutting-edge. As one interlocutor pointed out and many others also explained, “Chemical plants are nothing new. There are lots of plants that have to separate CO_2. Piping it around is nothing new. Storage of CO_2 is nothing new. We commonly inject CO_2, store natural gas. Joining it all together in a way that is economically feasible, that is new.” These multiple enterprises now claimed as CCS precursors shared one circumstance: they were not meant to provide knowledge of “nature” so much as to provide knowledge of a nature that has already been intervened upon, materialized into a chemical plant’s process structure, or in a space of the subsurface pinmarked with wells, or as stated, the integration of the two (a geological subsurface region and an industrial facility’s machinery).

By 2000 to 2005, publications of a peer-reviewed nature as well as commissioned reports and brochures began to proliferate. A range of public representations emerged, blurring the conceptual differentiation between CCS as something people do to *sustain* or *maintain* an industry, versus to *innovate* or *transform* it. In presenting CCS as ordinary, it can be framed as “based on existing technologies” (Hansson 2012: 81), thereby invoking qualities of being safe, known, and proven. Alternatively, it can receive funding meant for “energy transformed,” as named on a banner hung in a Queensland research center facility. At least one author has categorized post-combustion technologies as “sustaining” technologies for utility industries. In contrast, pre-combustion capture technologies are “disruptive” (Bowen 2011). During my fieldwork, people would craft divergent and personalized interpretations of whether CCS was or was not new as they told me about their relationships to it, embedding estimations of its novelty within larger judgments of its meaning, purpose, and value.

As the attention of “powerful, entrenched actors” (Stephens and Liu 2012:148) and other energy policy thinkers focused in upon on “geological sequestration” of CO2,[9] demonstration projects began to receive media coverage. Then something happened more quietly behind the scenes: the opportunity to embed carbon in soils, wallboards, cement, and materials other than subsurface geologies started to fall off the table for academic and policy consideration, or at least break away into separate scholarly communities. Specifically, the term “geosequestration” disappeared from all of the reports. “Geosequestration” or “sequestration” had been a label for the types of CO2 injection in which petro-extractive industries had expertise, namely geological injection; and the term had been used when deep geological injection was one “option” among many. But all the other options for where and how to dispose of CO2 then became rare in the reports, to the extent that what had been called “geosequestration” as one option among many became the common and mainstream definition. Once geological injection became mainstreamed as definitional of CCS itself,[10] the term “geosequestration” was longer necessary.

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[9] In trying to situate CCS amidst “innovation theory” by judging the nature of the “innovation” that CCS is, Mark Winskel argues that it should be labeled a “regime-led prospective innovation” (2012: 208) because “it is associated mainly with large, incumbent interests in the energy sector” (208). “It could be argued that compared to other energy technologies with climate mitigation potential CCS has among the highest levels of powerful, entrenched actors involved in a focused way in its advancement” (Stephens and Liu 2012: 148).

[10] Of course, as argued throughout this dissertation, whether “CCS” is itself a definitively-bounded and coherent object is contestable; even CCS supporters when writing peer-reviewed articles concede that it is an “umbrella term” (van Egmond and Hekkert 2012: S148).

Between 2000 and 2008, the global research endeavor took on greater intensity and the expected costs of CCS technologies grew significantly (McKinsey and Company 2008). During the first half of the 2000s, numerous CCS research and support organizations were established, such as the Scottish Carbon Capture and Storage research group in 2005 and the UK CCS Research Consortium in 2012 (Martínez-Arranz 2016). As a form of pollution control for sale to be installed in markets that do not directly penalize pollution, CCS was known to all of the industrialists I met as something that would incur cost to the facility that it was running on. Circa 2000 to 2006, the costs were commonly expected to emerge at US “$20-$80 per tonne CO2 avoided,” but from 2008, the language used in reports to express projected costs became more cautious, and the figures given became $90 to $100 per tonne of CO2 avoided, with the McKinsey report estimating that initial demonstration projects could even cost $135 per tonne of CO2 avoided (Shackley and Evar 2012: 158). A greater number of researchers and investigations appeared to have trouble replicating or confirming early, optimistic cost projections.

The time period between 2005 and 2012 nevertheless saw a massive spike in CCS project announcements, funding commitments, and article outputs globally (Martínez Arranz 2016: 132; Karimi and Khalilpour 2015). Australian CCS has received a total investment of $1.3 billion Australian dollars between 2003 and 2017 (Browne and Swann 2017, Australian National Audit Office 2017). The global financial crisis of 2008 was followed by spikes in the price of raw materials for building industrial sites. Australian CCS investments slowed: the window of greatest Australian CCS investment was 2009 to 2015. Yet after the financial crisis, elsewhere, the European Energy Programme for Recovery committed the equivalent of $US1.3 billion, while the U.S. American Recovery and Reinvestment Act of 2009 committed over US $3.1 billion. A great deal of expenditure was designated for CCS between 2008 and 2010: across the globe, a total of US$10.5 billion of new money was announced in 2008 and 2009, including economic recovery acts as part of that sum (Stephens and Liu 2012: 142). “The vast majority of CCS projects around the world have relied on a combination of public and private funding” (Stephens and Liu 2012: 143). Costs and responsibilities are distributed across state and national governments, research organizations, and private funders, such as coal associations. Yet even while publicly funded, the work of the Australian CCS research industry has not appeared to require supportive “public” attention in terms of citizen interest and awareness in order to continue to be funded. The research industry appears to speak directly to its sponsors most of the time, yet occasionally hosting public “Open Day” site visits (c.f. Loloum 2019). From 2002 to 2010, proportionally more attendees at the Greenhouse Gas Technologies (GHGT) conferences came from NGOs and the private sector, while proportionally fewer came from the government over time, and the proportion of academic affiliations has remained constant (Stephens and Liu 2012: 132).

In the 2000s, it becomes legally possible for the private companies to conduct CCS projects with public or private support or both, and later transfer responsibility for the long-term environmental effects of those CCS projects back to the public sector. For example, Alberta, Canada's 2010 legislation established the Canadian government as the owner of pore space within the rocks:

> Upon certified site closure, ownership of stored CO2 is vested in the Crown, which assumes all long-term liabilities (including claims in tort), when the claim is the result of activities carried out as part of an agreement with the government for injecting CO2 and the operator has complied with all other relevant regulations. [. . .] The resolutions to specific legal definitions have been pivotal in establishing legal and regulatory frameworks for CCS. Particularly important has been the qualification of CO2 as waste or as a commodity. This question has been partially resolved by excluding permanently stored CO2 from the list of waste, where disposal is prohibited under international marine dumping legislation and from the scope of EU waste legislation. (Evar, Chiara, and Scott 2012: 28-30)

In Australia, legislation also provides the opportunity for greenhouse gas projects "to surrender an injection and storage authority" to government, provided that the project company also pays a royalty afterwards to cover the monitoring costs that will accrue (Gibbs 2011:163–64).

In the 2010s, the industry met "a bit of a stall" as the expectation that multiple large demonstration projects, especially in the electricity industry, would be underway did not seem to materialize. CCS history itself became an object of peer-reviewed academic knowledge (Stephens et al. 2011; Günel 2012; Arranz 2015, 2016; Karimi and Khalilpour 2015) and retrospective government reporting (Australian National Audit Office 2017). Critical social research appeared suggesting that the CCS enterprise can be productively approached as a discourse, "hype," or fantasy (e.g., Asayama and Ishii 2017; Arranz 2016; Kush 2017; Marshall 2016; Hansson 2012). Indeed, the fraught professional ties, or lack thereof, between electrical power engineering and carbon fuel pollution control engineering is a major site of inquiry for this dissertation's work.

How is Engineering as a Field of Action Related to CCS as a Climate Strategy?

Engineering as a professional field of action is linked to CCS as a climate strategy because the social value of "engineering" is co-produced (Jasanoff 2004) with to the social value of promissory "clean energy technology" visions. Downey suggests this by arguing that imagined national goals for engineering are related to imagined goals for nations as such (1992, 2012, 2015). When social attention gets drawn to virtual representations such as CCS and other potential entities, "engineering" gets simultaneously constructed as a central means to realize these promises, increasingly so amongst all the many recipients of institutionalized government support and popular enthusiasm. There is a widespread, common critique in social research regarding energy and climate topics of the notion of a technical fix to a social problem (Pinkus 2016, Weston 2019, Moore 2015). Numerous related concepts have appeared, such as the "technical adjustments" that "obfuscate and efface the simple realization that humans cannot continue to live and consume as they do" (Günel 2019:11). CCS is a quintessential technical fix, and the social elevation of technical fixes thereby also elevates engineering as a panacea.

To study how and why social confidence in a technological fix can so persistently remain, even after its technologies fail to materialize at scale, requires considering how concepts of these "fixes" are co-constructed with the authority of the expert fields imbricated with them. In political contests around climate change policy, "engineering" as a mode of climate change response can be drawn upon to create a symbolic contrast with supposedly emotional, irrational, and anti-business demands of climate-concerned publics. Politicians and political appointees in Australia and the USA have suggested that climate change is "an engineering problem," in the words of petrochemical executive Rex Tillerson in 2012[11]. Shifting the social ascriptions of responsibility to engineers implicitly moves it away from other actors, such as citizens and governments, while along the way reinforcing the notion of market-based solutions to public concerns and implying that engineers have an unmediated responsibility to publics[12]. CCS and "engineering" share substance with one another when carbon engineers are granted authority to give public lectures and television appearances; feature centrally within government inquiries, commissions, official studies, and consultations; and represent possible fates for carbon dioxide

[11] Tillerson's full words were: "And as human beings as a — as a — as a species, that's why we're all still here. We have spent our entire existence adapting, OK? So we will adapt to this. Changes to weather patterns that move crop production areas around — we'll adapt to that. It's an engineering problem, and it has engineering solutions. And so I don't — the fear factor that people want to throw out there to say we just have to stop this, I do not accept" (Mooney 2016).
[12] See Chapter 4 for my ethnographic counterpoint to that.

as more or less necessary or possible without being forced to dialog with other knowledge traditions or social agencies on such questions. Because figurations of engineers are linked to figurations of engineered benefits, an investigation of the meaning of "engineering" as an Australian concept and ideal does relate to some of the ways in which Australian CCS has been anticipated and received; and vice versa,

From the above, readers should know that this dissertation brings CCS and "responsible engineering" together not because it assumes that CCS work always originates from individual personal "vocations" towards climate-repair, or because the author considers CCS to be responsible, but instead because CCS can be represented as a responsible or benevolent thing to do and also something engineering-dependent, thereby both reliant upon and contributory towards the authority of technological experts. But if this dissertation does not assume that CCS work is always experienced as a mode of responsible engineering, even if it can be represented as such, then what is the conceptual grounding for choosing to observe "responsible engineering" in the CCS topical area?

Generally, it is challenging to empirically study "engineering ethics" because the practices that a social scientist could consider "ethical" do not necessarily align with what a research participant would. For example, assessing a project's "environmental impact" in the legally-required mode, or alternatively, improving one's personal appearance in order to care for the brand of one's company, could be considered legal or aesthetic activities by person carrying them out but ethical activities to an observing scholar who chooses to find ethics in everyday life (e.g. Lambek et al 2010). Further muddying the issue, participants can use the term "ethical" in performative ways, such as to categorize "ethical investments" or to define the members of an engineering association partially by reference to their ethical excellence. In such ways, artifacts that are called ‘ethical’ proliferate in social life, but may not be experienced as such, at least not without a twinge of bad faith (de Beauvoir 2011[1949]). This dissertation project responds to the challenge of making “engineering ethics” tractable by adding in the term “responsibility” as a means to try to keep the focus on participant experiences, especially as related to the workplace or to a “professional” role, yet still hold possibilities of bringing under analysis experiences that the researcher herself would consider to have a moral or ethical inflection.

“Responsibility” conceptually suggests an ability to respond, as well as a duty or obligation to do so, and an assigned purview related to a role, making it a fitting keyterm to structure an investigation into whether and how “responsibility” is felt in new ways as climate change concerns intensify. Furthermore, responsibility can be ascribed or assigned (Busby and Coeckelbergh 2003); it is not merely felt from within—as part of a vocation or discipline that has already shaped a subjectivity. It is attached to people perhaps unexpectedly and without their consent or without their full identification and sympathy, making it an appropriate entry point to the study of a workplace-related conceptual experience in an advanced industrial society. Where to see “responsibility” can be an ideological choice. “Responsibility” can also be collective and institutional, and indeed can be part of cultural messaging quite independently of any “personal experiences” of it, so the term is appropriate as a means to study engineering ethics empirically yet not in a way that is excessively oriented to (or assuming the existence of) inner, subjective, individual and individualizing experiences. Lastly, responsibility is always (ir)responsibility, since whenever a particular conception of one of these comes sharply into focus, its negative space does as well.

It is important for this dissertation that “responsibility” is ascribed, not only felt; is located in collectives rather than in individuals; and has potentially damaging as well as benevolent effects to its configurations. Put differently, "responsibility" is to be identified not only in individual acts of goodwill, but also in collective acts of neglect, omission, or harm[13].

It is assumed, for this work, that the disciplinary and institutional norms of engineering contribute to the continuation of investments in CCS technology, and that there are ethnographically-observable modes of reasoning by which CCS is known and presented as a responsible technological intervention on a warming planet. This dissertation assumes that Australian scientific and technological institutions have provided the symbolic and conceptual conditions—the groundings for rationality and ethics—that have allowed carbon engineering research to flourish, and investigates these conditions and norms, the precursors and environment for the construction of Australian CCS as "responsible engineering."

What is Particularly Australian About CCS and its Research?

Australia's settlers have historically drawn on a subterranean inheritance of carbon-based and other resource wealth, while at the same time being extremely vulnerable to climate change. Fuel deposits have been considered state property that mining companies may lease from Australian states (Baer 2016). Australia is one of the world's largest coal exporters; it exports commodities more so than it exports technologies or manufactured goods. Australians are residents of the driest inhabited continent, who have been subject to devastating wildfires in 2004, 2006, and 2019-2020, and thereby at existential risk due to climate change. Although a student-led "divestment" movement since 2012 has contributed to critiquing climate policy

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[13] In dwelling upon "the School" as an example of an "ideological state apparatus," Althusser suggests that schools teach content that may include "simply the ruling ideology in its pure state (ethics, civic instruction, philosophy)" (29). With this brush, he is happy to tarnish the entire concept of ethics as an expert domain, posing it perhaps a means of accommodation to industrial orders rather than a means of contesting them.

inaction, the science, knowledge, and policy that would be explicitly inflected towards preventing climate change do not have strong institutional homes. As two examples, the country attained a so-called "Australia clause" item the 2007 Kyoto climate policy agreement that stated that it could count a reduced rate of deforestation as equivalent to an emissions reduction; also, the country tried to adopt a carbon pricing policy it began to draft in 2007 and which became effective in 2012, but this was repealed in 2014. Less publicly, the national science agency lost its climate science division in 2016.

As an energy commodity exporter, Australians were historically less vulnerable to the oil shocks that reframed many countries' relationships with carbon energies: "By the early 1970s, two-thirds of the country's [oil] needs were being met from local sources" (ATSE 1988: 781). Thinking through where the "energy industry" is conceptually located, most interlocutors see energy as many industries; in its multiplicity it includes electricity generation and distribution, gas mining and distribution, solar and wind power, and forms of analytical and office-based work.

Electricity research and coal research began as two separate types of investigation, but both exemplified a logic of science serving the needs of technological industries. To study the problems that electric power grids could fall victim to, the 1950s, 1960s and 1970s respectively saw the establishment of a "high voltage test laboratory" in Queensland capable of simulating lightning strikes to the electric grid, a "model power system facility at the University of Sydney," and "an electronic simulation facility at Monash University" (ATSE 1988: 785). The State Energy Commission experimented with wind power in 1978, reasoning that wind technology "is known to be economically viable in certain applications" and amidst the awareness that Western Australia's SEC had successfully brought wind power technology to bear upon the challenge of defending “remote mining and primary industries” from “future oil shortages” (ATSE 1988: 408).

Coal pollution was also investigated separately from the technological problems of running an electric grid, and both were separate from the technological problems associated with mining itself. Accounts of how coal pollution research was characterized in the 1980s deserves quotation in full because the author’s voice exemplifies a logic of assuming that science serves technology and technology serves industry:

> By the 1970s, when Australia was emerging as the world’s largest exporter of coal, it became clear that environmental pollution due to fly ash emissions from smokestacks was becoming a problem that was a potential threat to exports. The technology of electrostatic precipitation was too poorly understood to be able to collect fly ash sufficiently effective[ly] to comply with smoke emission regulations. This gap in knowledge was filled by a CSIRO team, to the considerable benefit of the coal export industry. (ATSE 1988: 786)

“Decarbonization threat,” defined in Chapter 2, relies upon the same logic as the fly ash problem the Academy of Technological Sciences and Engineering (ATSE) describes above.

CSIRO, the Commonwealth Scientific and Industrial Research Organization, was a government workplace for applied science and still exists as such. To socially locate what it means to be a carbon energy expert, it is important to know that Australian science has often been actual government work. Research expenditures by the Australian government increased greatly after World War II, as it did in many governments around the world (Forsythe 2017: 15). This research was initially located in the national research organization until about 1950, when Australian universities became more able to fund themselves through student enrollment fees (Forsythe 2017: 19). In the United States, the national science agency does not itself do research (NSF 2020), but rather funds it at separate sites. In Australia, however, the national science agency itself is a “government-based” researching entity (ATSE 1988: xxix), thus exemplifying "the substantial historical connection between the government and capitalism in Australian history" (Forsythe 2017: 18). Australia's CSIRO's scientists are not allowed to comment on policy (CSIRO 2020), but they are abundantly encouraged to make the political problems of any industry into their own scientific problems. The applied character of the agency's work can be seen in the alumni news it posts about its research achievements (which I receive, having worked for the agency from 2011 to 2012). Although recent briefs mention coral or the stars, they emphasize pharmaceuticals and crop, groundwater, or mineral monitoring technologies.

In the 2000s, CSIRO shifted from an emphasis on research programs, such as the "Cooperative Research Centres," to an emphasis on research partnerships (Howard 2007). A carbon engineering researcher remembers these changes as follows, as we sat together in a CCS research organization event. She frames the "CRC" as a type of business that was part of the CCS organization's past, and a "services company model" as its emerging present and future:

> The Australian government had over 200 CRCs. They used to be industry, government, academia. They are at topics where there is market failure. [14] Health, food science, the whole thing. There are still CRCs but funding is much reduced. We already have [had] 12 years of CRC funding" [for the CCS CRC.] We are transitioning [to a different way of getting financial support], almost like a service company model—estimated out. R&D projects, demonstration projects, utilization of existing facilities, commercial services. They could all be proprietary to the organization. IEAGHG is who they do some of their work for.[15] A services company model means the results that are produced are published according to a publication strategy.

By the notion of "a publication strategy," the speaker raises the question of ownership over the outcome of the knowledge work that eventuates during these projects. In any case, "[t]he

[14] By "at topics," I understood the person to mean that the research subjects of the CRCs encompassed types of technological problems that "the market" was not creating enough innovations to address.
[15] The IEAGHG is the International Energy Agency Greenhouse Gas Program. The speaker switches between "we" and "they" to describe the CCS CRC probably because her own affiliation with it has been changing, as many peoples' have.

increased proportion of external revenue for core CSIRO research reflects a growing commitment to engaging with external clients through business development opportunities" (Howard 2007: 3).

In the shifting model of how applied research is financed, as presented in the introduction of a 1988 volume on the history of "Technology in Australia, 1788-1988," Australian technological development can be constructed as a vulnerable and at-risk project:

> Science progresses in small quanta. [. . .] The production cost of each quantum is relatively low, accessible even to scientists in small countries. Technology, by contrast, involves the combination of masses of quanta [. . .] Costs are immense [. . .] the scientific contribution from small nations tends to flow into the international pool from which the technology generating major economies draw. It is for this reason that contributions to science from small countries rarely coalesce into technologies in the country of their origin. The respective roles of science and technology are therefore very different in smaller economies.

The project of creating new technology is framed as something that Australia experiences differently than so-called larger economies. ATSE's volume implies that the particular difference is that Australia and similar countries are structurally disadvantaged by the risk of doing science that would inform other country's technological enterprises without benefitting their own. Framings like it could serve as a justification for creating a science and technology policy that is more oriented to creating technology and supporting science that creates technology, as opposed to any other science. The author of this 1988 work explicitly contrasts Australian experiences with research and development to that of "the gigantic enterprises which pioneered technologies overseas," concluding that "the post-war policy of diversified industrialization produced a thin spread of technological evolution over many areas, with little concentration apart, perhaps, from the resource-based industries" (ATSE 1988: xxviii).

Australia also sponsors research through its taxation processes, as was defined for me in a corridor conversation at a 2017 energy industry business conference:

> The Australian government's largest innovation program. What it provides is: provided you are effectively carrying out experiments to test technical unknowns, if your turnover is <20 million dollars, you get a check back from the ATO [Australian Taxation Office] for cash. It has been a lot of popular [sic] in the startup community.

The emphasis placed upon "experiments" and "technical unknowns" in this spoken comment expresses the practical opportunities for rhetorical work around what counts as an experiment and what counts as a technical unknown.

As a social (rather than technological) scientist from a critical-theory (rather than "applied") tradition, I found myself doubly removed from the recurrent expectation that science's telos and purpose is "better technology," which made it all the more jarring and unexpected to me that Australians and their institutions so often seemed to be making that particular assumption.

First Substory: Privatization Relocates Energy Engineering

Institutionally, the "Australian energy system" has swung over time from a private phase to a public phase of centralized state companies and now is moving back into another private phase. In this historical arc, the situation of an "energy expert" has moved from that of a private businessperson to that of a government employee and back again.

Small private power systems were joined together by early technological industrialists such as Sir John Monash in the 1920s, leading to state-owned electric utilities, such as the "State Electricity Commission of Victoria" (SEC or SEC-V). As a retired expert in electrical energy and an activist on behalf of renewable energies told me in a car in 2018 as we drove on to an educational event hosted by an environmental NGO:

> Monash helped to make a public system out of private options. Around Melbourne there were different voltages, different frequencies. Urban air pollution was a problem . . . . I guess the government bought out the companies, standardized frequencies and voltages. 50 cycles per second.

As told by an electrical tradesperson, Australia's was one of "only two vertically-integrated electricity systems in the world.[16] The other one was in Canada." The time period from 1930 to 1950 saw state ownership of private power companies consolidated, resulting in "the virtual extinction of private power companies by the mid-1950s" (Booth 2003: 14).

After the electricity system became a grid in government hands,[17] electricity demand increased for a while, then ceased to grow as fast, ushering in an era of trouble for the sociotechnical networks. Australia's "country areas" were rapidly electrified in the 1960s, when electricity demand was growing quickly, with 6 percent to 8 percent more electricity being demanded each year, and larger and larger generator machines were installed at utility sites (Booth 2003: 4). Into the 1970s, electricity demand did not grow as fast as it had in the 1960s, and utilities also started to find that the larger generating machines they had installed had not been as good of an investment as they had hoped (Booth 2003: 4–5). From the 1920s until the 1980s, Australian thermal power station practices "generally followed practices overseas" (ATSE 1988: 398). Steam-power stations provided the most electric power in 1988, while gas and diesel engines and hydropower were also used (ATSE 1988).

In the 1980s, electricity prices started to rise for Australians, a trend that continued until the time of writing. Electrical utilities were having a hard time balancing their budget sheets: major construction projects were turning out to be more expensive than had been expected, and utilities were experiencing debt and other financial problems. As a former Commissioner of the

[16] In energy, "vertically integrated" means one business owns the fuel mines, the energy conversion utilities, and the distribution networks as well. For details on the institutional structures and policies immediately before privatization, see Clark (1986).
[17] Grids are not the only way that electricity can be delivered; in the United States, these were preceded by small, battery-powered electric-powered objects (Bakke 2019:164).

State Energy Commission of Western Australia and an executive and consultant to subsequent private businesses, Robert Booth[18] describes the state businesses in his book:[19]

> Until the decade of the 1990s, the electricity utilities in each state generally consisted of various forms of statutory authority (organizations established by statute, with ownership vested in a state government). [. . . .] The first of these statuatory authorities, and the model that all other states would generally follow, was the State Electricity Commission of Victoria formed in 1921 with Sir John Monash as its first Chairman. (2003: 14)

In the 1990s, these entities were taken apart, creating separate private companies to generate, transmit, and supply electrical energy. Victoria's privatization process was the earliest and the most extensive among the Australian states. By comparison, there are some similar elements of energy infrastructure that have remained state government property in states such as Queensland and New South Wales at Booth's time of writing in 2003.

The privatization process seems to have been touched off by two instances of seemingly excessive infrastructure investment in Victoria, Australia that attracted the interest of the Australian federal government, which made inquiries in 1989 and 1991. "Reform" appeared necessary because the SEC-V was spending money constructing electricity infrastructure that "was simply not necessary" from external points of view (Booth 2003: 39). The judgments being made about the need for reform were grounded on trends of frequent and lengthy times off-line for power plants, "extreme" "levels of over-manning," project cost overruns, utility debt, and high power prices in Victoria relative to those of other states (Booth 2003: 43). There seemed to

[18] In case it is of interest, Booth does not appear to be politically aligned with the union movement, since he alludes to the "economic strategy" of the heavily unionized Victorian power sector of the 1980s as "out of control" and what "led to drastic actions being necessary in the 1990s" (2003: 29).
[19] Booth's book was generously given to me by a man I had met at a "Carbon Utilization Conference" in Queensland whom I later interviewed in downtown Melbourne.

be a contest between state-level and federal-level thinkers about the desired goals the system should serve and how its success should be measured.

In August 1993, the planned separation of the SEC-V was announced, together with the formation of new managerial committees and units within the state government to advise on the process. Unfortunately for the goals of this separation, one of these three new businesses (the one oriented towards high-voltage transmission lines) made a fairly immediate and successful move to buy up chunks of technological property that had been designed to be part of the other two businesses, and the new oversight and managerial committee structure "was powerless to combat this development" (Booth 2003: 49). There was no clear solution to the emerging private monopoly, but much governmental ink appears to have been spilled afterwards trying to oversee these businesses in a way that would ensure that, for instance, citizens in remote areas were still provided electricity. The formal sale of Victoria's distribution businesses continued throughout 1995, unfortunately accompanied by rising electricity prices (67) that citizens were still feeling as they attended meetings about this during the time of my fieldwork. "By mid-1999, the four-year privatization program was complete, and the [Victorian] government had received total proceeds of $29.5 billion from the sale of the electricity and gas industries. An estimated $160 million was paid to consultants and advisors as part of this process. The net public sector debt had been cut from about $32 billion to less than $10 billion by mid-1999" (Booth 2003: 75).[20] Interlocutors of mine in power systems engineering have recalled this as an instance of the government looking after its own financial bottom line.

[20] In another state, South Australia (which was not an empirical focus for this chapter), costs and financial transfers were as follows: $5.5 billion was earned by government, where $7 billion had been expected; and "the consultancy and success fees associated with the privatization process had exceeded $113 million by early 2001" (Booth 114).

By means of the privatization experience, the financial market value of the electricity industry infrastructure increased greatly: foreign capital flooded into these new businesses, and they became, arguably, “financialized.” For example, Victoria’s distribution infrastructures sold to U.S. businesses or U.S. and Australian business consortia for a total of $8.3 billion dollars, even though they had formerly been valued at about half of that (Booth 2003: 68). The revenue from these sales accrued to the state. Regarding the effects of the financialization of this infrastructure, Booth points out (from a 2003 perspective) that now that the market value of the electrical energy industry looked higher, returns on those investments would need to be gained:

> At the time, no one seemed to worry about the fact that, if the previous SEC-V was unable to service a level of total capitalization of $9.5 billion, could the newly privatized industry support the servicing of $23 billion of a mixture of higher-priced debt and equity—even given the fact that substantial economies (i.e., opportunities for cost-cutting) were clearly possible within the industry? (72)

I conjecture that this could have transformed the collective purpose of some types of energy-expert work that must have been done within those businesses, away from serving electricity customers and towards serving the needs of investors to receive a return. As far as Booth’s opinion, partway through his book he cites a 2002 study he contributed to coauthoring, which draws the following historical interpretation. During the 1990s and early 2000s there occurred

> regularly decreasing retail prices, improving labour productivity and power plant availability, and the maintenance of good thermal efficiency during the period up to 1998. These were the years when structural changes were being made and competitive forces were being introduced both within and between the states. The study also pointed out, however, that all these indicators have flattened out or turned negative since 1998 [. . .] The study puts forth the proposition that the coming of the NEM [National Electricity Market] has resulted in a frittering away of the early economic benefits of the structural reform/competition phase. While the early phase of structural reform was undoubtably beneficial, it is arguable that the excessive overhead, transaction and regulatory costs, and the inherent flaws in the NEM rules have subsequently prevented a fully competitive market from existing, and may have made the achievement of substantial economic benefits impossible. (225–26)

Rather than a single event, the privatization process was a lengthy phase of sociopolitical experiences for Australians. It included the creation of not only new businesses, but also the creation of new governance functions and entities who could stage and manage a “National Electricity Market.” Yet those consultants who had experienced it as a time of wealth and new jobs did not appear in my interviewee pool, compared to people who felt a different pattern of experience.

The process of privatization was remembered by interviewees as resulting in a decreasing number of jobs in the electrical energy industry—from 25,000 to 11,000 in about a three-year interval. As an electrical tradesperson interviewee told me, where the workplace’s initials (SEC) had been taken to refer to the words “slow, easy, comfortable,” the experienced change created a legendary difference in workplace experiences, as capably narrated in a documentary film:

> Ten thousand people worked in the State Electricity Commission [of Victoria]. That company was integral to the community. Nothing in the SEC was done without. We used to view ourselves as providing an essential service. I am a third-generation retired coal operator. It was corporatized and became Generation Victoria. Ten thousand to 2,500 jobs. Private companies run from boards in far-away places; the culture was destroyed.

As presented in the film “Our Power,” the temporary and subcontracted labor arrangements that replaced large-scale state employment quickly threatened not only workers’ sense of their social embeddedness through work, but also the emotional conditions in which they were free to create a physically safe working environment. Economic vulnerability in an immediate sense flowed into a generalized and physical precarity, threatening life and limb.

> We have no place in society anymore. Our reason for being is gone. This connects with being on-call casual. So you will have a list [. . . .and if you aren’t called, it’s that you’re] either the bottom of the phone call list or dropped off the bottom. You sit at home. You don’t earn any income at all. People learn really quickly. The workplace is becoming more and more dangerous because no one wants to put up their hand up and say anything.

Overawed by confronting one's replaceability with the feeling of being on the bottom of a spectral "list," the speaker experiences temporary work contracts as rearranging the meaning of discussing unsafe workplace as a social act. Whereas doing so once would have been unremarkable and ordinary, now it could be taken as changing the employability of the person. This is a quick logical leap from comprehending that being able to be present and working at all was an extraordinary event, rather than the normal case. Here is one more such account of the experience given in the documentary:

> I witnessed the loss of engineering expertise. The pathways in which they came. One of the tremendous things the heavy engineering (auto making, power sector, steel manufacturing) [had brought about, was changed.] With the decline of industry, the training pathways—the SEC-V had tremendous training setups—the training of the new—the training got changed. The number and quality decreased. In Port Kembla in Steel, a large company, the largest company had a large training session. When the industry closed . . . I am a product of that particular system. [Over] 20 years, a decline of the economic sectors, and government. What is the Institution doing? Is that style of engineering training [obsolete]? Do we not need this type of people? Perhaps not. Environmental engineering: it is what we need. Software development, renewables: the opportunities are different. I have been through the heyday of Australian manufacturing. We have moved [on].

To dwell on these memories as a feature of Australian energy history is essential to comprehending the public meaning of "energy engineering," as it was held, particularly in the immediate vicinity of the CCS project emerging in Victoria, Australia during my late fieldwork. The initial shedding of technician, tradesperson, machine operation, maintenance, or monitoring work seems to have decreased the electricity industry workforce in a very socially visible way. But this was followed by a less-visible restaffing and increase in different kinds of electricity industry work. Instead I conjecture that the staff was office-based legal, regulatory, clerical, strategic, and communication-oriented in nature, and that that centralized "human resources" and administrative staffing for centralized government companies were replaced by a duplication of these same functions in different companies that were now nominally competing with each other,[21] as well as new types of work in branding and marketing possible alternative types of electricity.[22] From 1997 to 2012, “the number of managers in the [Australian electricity] sector has grown from 6,000 to 19,000,” thereby changing the ration of managers to workers to 1:9 rather than 1997’s 1:13. “In contrast to this, there was a much smaller increase in the group of people who are directly involved in producing electricity” (Richardson 2013).

Recently, solar panels have been expansively installed in Australian single-family homes, against a backdrop of exorbitant prices charged for power by the electrical utilities. As presented at an evening meeting of a home sustainability interest group in 2017, each month 90,000 photovoltaic installations take place across Australia. Arguably, domestic electricity has been doubly privatized: not only are the utilities no longer government businesses as they once were, but also, energy generation is being installed upon private homes with spare capital for it.

Unfortunately for collective flourishing, retail electricity price increases across Australia “have not reflected the rate of reduction in fuel costs, labour costs and interest charges” (Booth 2003: 230). Energy experts speaking at public events in 2017–18 did not offer many insights into how this painful situation had originated or how it could be fixed other than saying that Australians were suffering from an overabundance of electrical power in their system rather than

[21] The notion of “getting more competition started in the energy sector, to bring down prices” is considered by this dissertation to be highly ideological, since “the market” that was Australian electricity at the time of fieldwork was artificially suspended amidst an abundance of laws and regulations over who, how, what, where, and when would electricity be bought or sold at any given time. As I was conversationally told by energy experts, energy companies could also adopt a “portfolio strategy” and buy multiple generation facilities that would from the outside, look like competitors, although in practice they were managed by the same corporation. I only consider Australian energy economies to be “like a freely-competitive market” to the extent that a hobbyist's saltwater aquarium should be considered “like a wild, free ocean.”

[22] Of course, there are no “types of electricity” in a material sense, which has not stopped companies and people from buying and selling this commodity as if it were a branded good: more or less green, more or less “fresh” (Baker 2014; Calo 2015).

a deficit, as well as the associated high network costs to manage all of it. Or they suggested that perhaps citizens were not properly informing themselves and switching to lower-cost providers.

Second Substory: Social Sciences of CCS Serve Technological and Industrial Needs

> She says someone from Germany has contacted her for social science. Am I that person? [. . .] A different lady asks me if I work for the industry, a second time. I say that I do not—they do not have a need for a person like me.
>
> –Notes from a carbon storage opposition group meeting, February 2018

> [Government employee] wants more information about what is my relationship to the University of Melbourne and to the Peter Cook Center; do I know of them? I tell him/her that I am supervised by the chair of the Anthropology Department and that her research work is in Papua New Guinea and with the fishermen of Lake's Entrance. [Government employee] says s/he is asking because an eminent University of Queensland professor has just, through the Peter Cook Center, made a proposal to study social and political drivers of resistance to CCS; and am I hooked up with that? No.
>
> –Fieldnotes on a coffee meeting with a government employee, October 2017

> "Are you industrially-funded at all?" The journalist, in a black crêpe shirt, has this as her only question for me, as we cross paths on the porch of a holiday house in Golden Beach, Victoria, and I have tried to explain why I am there taking notes.
>
> –Fieldnotes, 2018

This section explores how interactions like these, in which despite my university affiliation I was assumed to be a researcher seeking to fix industrial problems, were common and indeed normal in Australia. I suggest that although social studies of engineering, science, and technology have investigated CCS, they have often directly shared the problem-definitions and investigatory interests of their objects of study. In other words, the problems managers and agents of technological change are having with CCS technologies are becoming the research problems for the social studies of CCS. I argue that the vast majority of all carbon engineering social research has either been *for* an audience of CCS professionals themselves, thereby continuing to repeat and naturalize assumptions typical within that community and class without addressing how such assumptions are created and maintained, or, alternatively *about* carbon engineering, but from a farther distance allowing applicable but broad insights[23].

As the epigraphs present, the industries carrying out CCS projects are themselves commissioning research. Peer-reviewed research that I categorize as *for* the CCS industry is extensive: the small number of papers that try to conceptualize the industry itself are dwarfed by the huge numbers of papers that draw their research objects to exclude the industry itself, except as a purveyor of politically-neutral scientific information providing "options" for decarbonization's properly political processes, a characterization which the events reported in Chapter 2 of this dissertation contradict.A large set of articles exist that the editors of a volume on CCS-related social science collectively label as "acceptance research" (Markusson, Shackley, and Evar 2012). This body of work presents "public acceptance" as a technical problem to be solved (e.g., Ashworth and Quezada 2011; van Egmond and Hekkert 2012; van Alphen et al. 2007), rather than an absence comprising an authoritative voice of dissent. "Acceptance research" literature is characterized by a liberal injection of technological terminology from the CCS industry, and also by the assumption that CCS actually mitigates climate change. Papers typically reaffirm the International Energy Agency (IEA) or the Intergovernmental Panel on Climate Change (IPCC) as the authorities whose assessments of CCS are most authoritative, and who have already settled the question of carbon engineering's ultimate meaning and value.

Hansson (2012), Bäckstrand et al. (2011), and others claim that the acceptance research literature serves a normative goal of streamlining the adoption and use of carbon engineering: "Although several communication and acceptance studies emphasize the importance of two-way

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[23] Prior research by Stephens et al (2011), described later in this section, differentiates publications that address ''risks to'' CCS and ''risks of'' CCS (384). Her work inspires my next step of differentiating research "for" versus research "about."

dialog with the public […] the ultimate goal of these research activities is often simply to accumulate knowledge of how the public can be made to favour the technology more" (Hansson 2012:84). In other words, acceptance researchers are not questioning the goal of CCS deployment in how they frame their work, but instead are serving that goal and making their work its instrument. In doing so, they choose not to conceptualize from scratch whether the technology has value or serves its nominal purpose, but instead they delegate[24] those forms of thinking elsewhere.

There are many consequences from this abundance of highly positional work, both for the conceptualization of "the public" and also for the conceptualization of "the technology." Acceptance research papers (e.g., Ashworth et al. 2019) frame "people" as isolated from political collectivities (such as representative government), but tag them with demographic characteristics such as location and nationality, and consider them subject them to what Corry and Riesch call an "information gap" (2012). Furthermore, these papers make CCS technology sound like a definitively-bounded set of specific objects, perhaps more than it actually is: "The idea of 'acceptance' smuggles in an assumption that CCS technology is a given entity, rather than a discourse—i.e., a social fact that can be constructed in fundamentally different ways" (Corry and Riesch 2012: 92). If research on CCS is often the risks *to* CCS, not just *of* CCS—yet people not affiliated with the industry would mainly think of risks *of* CCS—this may intensify a process named by Stephens et al.:

> [A]lthough the CCS community may be influencing decision-makers and successfully garnering political support for advancing CCS technology, a potential disconnect with the concerns of a broader public is deserving of more attention. (2011: 379)

[24] Regarding logics of delegation, see Chapter 4 and the Epilogue. Although delegation within the acceptance researcher community is not investigated in this dissertation, the citational patterns named here suggest the possibility of its existence.

This is a way of saying that the research problems taken up by most peer-reviewed publications describing CCS are asking and answering questions that exist within a constricted problem-space (Scott 2004) of sociopolitical thought, in which "industry's" problems with "community" count for *much* more when measured by publication numbers than "community's" problems with "industry." Arguably, members of the applied research community—including the social scientists practicing acceptance research—are merging their intellectual optics with those of other carbon engineering industrialists, regarding the nature of "energy problems" that exist and what sort of a social challenge energy-related rationality actually is. Their individualizing optics make invisible social patterns and processes except insofar as they appear within the attitudes, beliefs, and values of individuals. The existence of this "acceptance research" literature can be interpreted as an example of "client orientation" (Calvert 1962: xvi) by social scientists,[25] where industrialists advancing CCS technology are the clients. The numbers of publications provide evidence of a large-scale pattern of choices to accept the definition of a problem a client gives instead of re-defining the sense of the problem according to one's own expert awareness of what should be considered a problem.[26]

Direct, focused, and interpretive social science that is *on* but not *for* the CCS research industry is nearly nonexistent. Because CCS in its particularity is not a sharp and focused interest for interpretive scholars who instead address technology, climate, and energy in broad ways,[27]

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[25] As a means to conceptually unpack the ethical imaginaries of American mechanical engineers, from 1830–1910, Calvert (1967) distinguishes between "colleague orientation" and "client orientation" as two answers to the question of which moiety was the ultimate arbiter of responsible and desirable practice: those who purchase expert services, or those who are peer experts.

[26] This is discussed further in Chapter 4's sections addressing "The Box."

[27] Landecker and Kelty (2009) observed a great expansion of sciences post-WWII, with consequences for social studies of science: "Much work directed at science in this time period in

there have been few theoretical papers studying how carbon engineering's meaning and value arises through social processes. Interpretive peer-reviewed studies that discuss CCS as a large-scale social project do exist, but they are few. It appears that CSS has been poorly known to people, including social scientists and humanists, whose daily work does not tangle with "energy policy" concerns. The few existing interpretive studies typically compare facts from the industry's history to theoretical concepts such as "epistemic community" (Stephens et al. 2011), "hype" (Arranz 2016) or "defensive fantasy" (Marshall 2016). Or they may use interviews and document analysis to attempt to discern characteristic modes of communication amongst carbon engineering professionals. Declan Kuch argues that "CCS projects are primarily framed through oil and gas industry worldviews, rather than more broadly built through public engagement and policy" (2017:1). "Risk" in a CCS project therefore can mean risk to the company, he suggests, with people being a source of risk rather than what is at risk (2017). Another set of interpretive scientists have used analysis of the contents of "three CCS community publications" from September 2006 to December 2009 to sort publications into those that describe ''risks to'' the technology—risks that may slow down the advancement of CCS—and ''risks of'' the technology—risks that may result if CCS is advanced:

> Although publications showed acknowledgement of various kinds of risk, the vast majority of articles in the newsletters are characterized by a sense of optimism [. . . .] The typical framing of CCS consists of briefly mentioning a number of risks to the development of CCS. However, the risks are, in most cases, described as being very likely to be manageable [. . . .] Significantly fewer of the articles frame "risks of" CCS. (Stephens et al 2011)

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the fields of sociology, history and anthropology of science and technology is conducted on specific cases, people and places. There are many case studies and few synthetic works to give one ways to stitch together these case studies into some larger sense of what has happened, particularly since World War II, save by making grandiose generalizations about life, or information, or capitalism." (177) Studies addressing life, information, or capitalism are what I consider purveyors of "broad" insights.

What Stephens et al. (2011) are on the track of is that the industrial publications align their authorial perspectives towards an implicit consensus that risks *to* CCS are much more interesting topics upon which to write reports, rather than risks *from* CCS. Perhaps these should not be surprising tendencies for industrial publications, but what is surprising is the scale: the large volume of brochures, reports, news briefs, status reports, and fact sheets printed by researchers, commercial CCS proponents, advocates, and analysts:

> CCS technologies mainly exist in laboratories, small-scale pilot plants and the imaginations of developers and promoters. Nonetheless, a large volume of CCS papers and documentation has been produced by a wide range of actors, including scholars, engineers, business representatives, politicians, journalists, and ENGOs. The common theme running through these texts is that they present discourses about expectations. (Hansson 2012: 77)

This oeuvre of predictions, optimism, and reports of successes (incompletely public) assumes that carbon engineering projects are necessary and proceeds from that assumption to consider how to intervene upon existing material, social, and political relations so that the technology can flourish. Problems with the technology are taken as rationales for increased investment.

As a counterpoint to this industrial gray literature, there is a non-peer-reviewed literature of critique built by journalists, environmental NGOs or think-tanks, and bloggers, newspaper columnists, and editorialists. By tackling perceived flaws and expense overruns in CCS projects, they often express that CCS is expensive, dysfunctional coal-cleaning technology, and coal can never be clean. Problems with the technology are taken as reasons to socially learn and know that CCUS is nonviable, destructive, and a waste of financial resources and a reason to decrease investment as well.

My position as an ethnographer was profoundly isolated and isolating because the intellectual problems I found compelling did not anticipate the CCS industry as their main audience, nor were they limited to comparing the industry’s promises to its actions in the mode of a critical audit. Unfortunately, I found few traveling companions in the published literature who were comparably interested.

A Note on Representational Ethnography

Subsequent chapters of this dissertation deliberately adopt a representational mode of ethnographic writing, since common objections to such a writerly practice are not applicable to its circumstances. First, the critique that representational ethnography creates false totalities, such as bounded ahistorical "cultures" (Clifford and Marcus 1986), will not be borne out by this project: its representations of carbon and energy engineering are scaled as solitary moments and snippets of conversation that do not appear to "add up" to a coherent, bounded portrait of a single location, institution, community, discipline, or other presumed totality. Conspicuously not portrayed in comprehensive detail is the carbon capture and storage research organization which was an essential fieldwork site. That workplace's daily dynamics of conversation with funding sources, funding recipients, and potential or former collaborators are presented only in aleatory ways that do not add up to portraiture—or to the extent that they do add up, they portray a totality beyond the walls of any institution, unpinnable to one corporate name. "Carbon and energy engineering" thus emerges as hazy and amorphous, yet definitely "cultural." The dissertation thus joins with other ethnographies of laboratories (e.g. Latour and Woolgar 1986, Traweek 1992, Langlitz 2012) whose work is not done: the work to keep exposing how wrong it has always been to associate technological expertise and masculinized "objectivity" with freedom from any behavioral requisites other than to speak timeless truths (Keller 1982, Haraway 1991).

Secondly, representational ethnography can be critiqued as taking advantage of participants' trust to enmesh them in an endeavor outside of their control or awareness, yet socially consequential for them (e.g., Stacey 1988). These critiques are based in a political desire to protect some aspect of what is being studied. However, this project ultimately does not adopt a protective pose towards "carbon engineering," although towards people[28] and institutions who gave their informed consent upon the assumption of promised anonymization, it does. "Carbon engineering" does not need protection from social science: it has been highly able to project itself, much more so than the knowledge traditions from which ethnographers write (c.f. Nader 1969, Macintyre 2010). Instead, this dissertation mobilizes a style of representational ethnography towards a critique of engineering: a critique of how its field(s) of practice, knowledge, and ethics are consistently attributed great credibility, coherence, and applicability—in a word, authority. The authority of the objects studied in this project is so great that they are at minimal risk from one heretical representation that pauses to asks about groundings of their authority, rather than hurrying to reaffirm it.

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In order to leave the Introduction sufficient space to convey the main arguments and the structures of the entire dissertation as well as ethnographic information, Chapter 1 has had to carry some theoretical, definitional, and historical work regarding the dissertation's approach to CCS. This first chapter has oriented readers to the institutional inheritances of knowledge, personnel, and socio-political expectations that have formed the CCS research industry. It has sketched how CCS is industrially located, how it has been politically located in global climate change mitigation projects, and how it is situated within Australian anxieties about energy,

[28] All research participant names have been changed in this dissertation, except for those of two social-scientific researchers and one "public figure" who deliberately permitted or requested to be named. At times, gender and other identifying characteristics have been blurred or exchanged amidst interlocutors who have been represented as characters within the work.
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climate change, policies, and vulnerabilities. To contextualize CCS as "Australian," it has been appropriate to give two types of detailed information summarizing the expectations and experiences that research participants typically brought with them as they heard about this dissertation project. First, participants' willingness to be part of an ethnographic process were shaped by their expectations of how "social sciences of CCS" have typically been pursued. Secondly, anything people could say about their engineering-adjacent careers and their knowledge and expectations about expert responsibility had a good chance of having been in some way been formed by Australia's historical relocation of "energy expertise" through industrial privatization. Next, Chapters 2, 3, and 4 will provide archival and ethnographic material to further articulate how institutional structures configure responsibility and knowledge within carbon engineering.

CHAPTER 2: INDUSTRIAL METONYMY

Financial Logics of the Formal Status "On A Transition Pathway", Or, How Coal Becomes Clean

Representations of environmental technoscience, which the first chapter theorized through "ideology," "sociotechnical imaginaries," and "performative speech," are consequential. This chapter examines ways in which they have been *financially* consequential in Australia. Empirically, it explores clean energy investment decisions and the extent to which contestations from alternative epistemic groundings are able to sway these. Two forms of investment are portrayed: that of a consumer-facing bank, and that of an Australian government investment vehicle. Afterwards, ethnographic representations are made of the social lives within which the work is done (the work of providing expert representations that inform financial decisions, and of contesting those representations). This chapter builds to a definition of the neologisms "industrial metonymy" and "decarbonization threat."

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In late November 2019, an Australian environmental NGO emailed me with an "opportunity" to contact my Australian bank about the fine-print details of the business they were conducting with mining companies. Seemingly occasioned by my bank's recent public promise to cease financing thermal coal[1] mining projects by 2035, the email explained: "2035 is much later than the 2030 deadline that OECD countries have called for, and there are still no policies to reduce exposure in oil and gas." But if I clicked a link to a preaddressed email and customized it, I could "Tell the bank getting out of thermal coal is the right thing to do, but they

[1] Thermal coal means lower-quality coal destined for burning, as opposed to higher-quality coal destined for conversion into the carbon of structural steel.
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need to confirm this applies to companies who are trying to prolong or expand the scale of the industry." In other words, I should ask my bank to please tell me that they were indeed holding recipients of their own loans and other support to the same standards to which they themselves professed to hold for the cessation of coal-related business practices. Moreover, I should ask them to tighten the time-horizon and the semantic meaning of their advertised departure from financing coal by confirming the standards to which their clients would be held.

Gamely, I did just that. "My" letter (in practice mostly authored by the NGO) named specific coal companies at its end that "I" assumed the bank would no longer be working with, since such companies are "attempting to expand the scale of the fossil fuel industry or prolong it well beyond deadlines by which we need to have moved beyond coal altogether." Five days later, an email address from the bank whose "name" field was Corporate Responsibility unexpectedly returned my message, affirming that "An orderly approach to the low carbon transition is important" and that the bank has not only provided substantial funding to "130 renewable energy projects," but also has signed into a group of 30 banks that have developed a set of "Principles of Responsible Banking" affiliated with a UN subsidiary. Evident in this reply was both a concern for "order" as well as the notion that trust-marks (Rogers 2010) and principles are evidence of responsibility. What's more, the email leveraged a concern for privacy in order to defuse my very pointed inquiry into whether the bank's advertising had underpinnings in practice, as well as refer me to specific pages of their sustainability report via additional contact information:

> In respect of your specific question, in the interest of customer privacy we can't comment about particular customers or transactions. However, I note that in our announcement we highlighted our commitment to continue supporting current coal-fired power generation customers implementing transition pathways.

Mediated by the NGO's intervention, I had tested the limits of my ability to change the work practices of a company I indeed patronized, but within my limited capacity as a checking and savings account holder. My test had failed because my relationship with the bank was held apart from the relationship they had with their other, larger, customers. As staged in this response, it appears that some unnamed power generation companies doing business with this particular Australian bank are "implementing transition pathways"; and the fact that they are doing so grounds a counterargument against my request to cease support for "companies who are trying to prolong or expand the scale of the industry."

In receiving this reply, I felt as though I had entered a usually-overlooked moral switchyard, where propositions—like railway trains—arrive on one track—*you must stop working with companies who are extending the coal industry in time or scale*—and depart on another—*if our customers, who deserve confidentiality, are "implementing transition pathways," we will keep working with them.* This switchyard is cloaked in the shadow of client-patron privilege, as well as other dynamics such as the tight "nexus" between fossil-fuel-extraction and Australian state-formation (Baer 2016), as well as the question of who has the authority to speak for the efficacy of any emissions-reducing project. Within this shadow, I cannot perceive what, if any, substance there is within a "transition pathway." If fact this is unknowable because even the clients' names are hidden from view; yet the "transition pathway" concept is financially consequential for a coal company understood by other businesses to be traversing it. I declined to email further, aware that the force of a direct critique against miners' (represented) plans to expand mining had been countered with their (represented) plans to attain "transition." This darkened switchyard of large and anonymous rhetorical cross-currents is no place to travel by foot alone.

An investigation of the social life of businesses that are "implementing transition pathways" lends insight into the social life of the carbon engineering research industry, because as U.S.-based financial professionals have told me, "cleantech exposure" can make an investment portfolio more likely to receive high ratings under certain existing schemes for measuring "responsibility."[2] Given that markers and certifications for excellence have consequences for the products and projects that advertise them (Rogers 2010), if CCS is considered to be "cleantech" or related to "transition pathways," it will fare differently in receiving financial support from a multi-institutional ecology of lenders and grantmakers than it would have otherwise. Querying this difference, this chapter contends with the interlocking financial and representational regimes that partially configure CCS as" responsible engineering" within Australia's public reason (Jasanoff, 2004, 2012), as it relates to rumors of an energy transition[3].

Specifically, this chapter characterizes the epistemological underpinnings of public statements about CCS technology that appear within "submissions" from energy-related experts

[2] In the words of a business advice book addressing entrepreneurs who would like to create lucrative private businesses that interact with governments: "Regulatory hacking holds immense potential across the world of social impact, but arguably holds the most potential in the context of CSR [. . .] because of the scale: Responsible business practice initiatives now cover a significant proportion of global value-chain activity and therefore cover a huge amount of economic activity." (Burfield 2018: 219)

[3] Contra High and Smith (2019)'s characterization of current energy research in anthropology, this research does not consider itself to be witnessing an "energy transition" nor does it consider itself to be advocating for one—for further discussion please refer to the Epilogue.

to the Australian government.[4] After introducing CCS finance generally, it describes the making of the Australian "Clean Energy Finance Corporation Amendment (Carbon Capture and Storage) Bill 2017," delineating what kinds of investments are considered "clean" and thus worthy of funding by the Corporation (hereafter CEFC). The negotiation between contending submissions, later followed by a parliamentary hearing, renders visible Australian configurations of knowledge, ethics, and political authority as they pertain to representations of science and technology. This chapter argues that partially by means of "politically powerful visions of actionable futures" (Beck and Mahony 2018) and the modeling technologies that conjure them and stand as their evidence, the problem of climate change is rhetorically distilled to a sole problem of "CO2" solvable by coal technologies and experts. Moreover, as evidenced within the CEFC inclusion governance process, carbon technologies are rhetorically framed as "clean" by scaling partially applicable qualifications into more expansive ones,[5] while advancing notions of parity, equality, and "technology neutrality." Within this scalar maneuver, we can see a fusion of scientific, industrial, and governmental authority about how carbon dioxide (alone) is the key harm of climate change; rhetoric that sustains fantasies of technological mastery (Marshall 2016).

The prior chapter has contextualized carbon engineering amidst Australian institutions for energy and applied science, but it has not thematized climate change policies, or the embedding of CCS within regimes of representation, as discussed in this chapter. Below I detail how carbon

[4] Essays about the advisability of a course of policy action, solicited and posted publicly, comprise a form of evidence characteristic of "public reason," which Jasanoff defines as "what ruling institutions do in practice when they claim to be reasoning in the public interest" (2012). This process is infused with a state claim to legitimacy, as the fact of having considered the "options" will then be able to legitimize later actions as "reasoned."

[5] For example, "clean" in one regard can be scaled to mean "clean" in multiple regards.

engineering has been paid for. I then offer an account of “the inclusion,” as this policy process could be titled[6], and a conceptual definition of the representational process. I conclude with a few glimpses into the role of models in legitimating CCS—or not.

The CCS research industry is a part of a larger set of research institutions that accept private financial support from petroleum, coal, and power technology companies, as well as receive direct subsidies from state and national governments and industrial bodies[7]. Australian government funders have supported CCS, claiming that by doing so they are preserving the economic base of their fossil-energy-exporting nation (Coordinator General 2006; ZeroGen 2009). In contrast, renewable energy advocates have been troubled by its potential to keep fossil-energized electricity in use (Burton 2014, Mares 2011), while journalists have painted CCS research investments as subsidies for oil and gas companies (Danson 2015, Nelsen 2015).

CCS appears financially and intellectually related to petrochemical industries at all times, offering new forms of work and new opportunities for generating profit and intellectual property. Yet CCS is only rarely related to electric generation facilities and yields them no financial benefit, except through the potential sale of CO2 to petrochemical industries, or via influxes of research funding and other government support. As Chapter 1 mentions, few electric generation facilities around the world have effectively used CCS technologies thus far. A key reason for this is that carbon pollution control raises the cost of electricity substantially, demanding the expense of extra power in order to separate the carbon dioxide, compress it, and inject it into the earth’s

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[6] By CCS research industrialists, this could also be called “the opening of the CEFC;” and as will be discussed below, the ideals that structured it from the carbon engineering point of view were “policy parity” and “technology neutrality.”

[7] This modality of support contrasts to competitive processes within government-funded national bodies, the alternative through which, for example, American anthropology research is supported.

crust; not to mention all the new machines required to install on-site to complete the process. Some kinds of "capture" technology are known to be expensive, yet gas processing separations that are a required step of methane production are not: "Once you burn it, it is expensive. The CO2-natural gas separation is not expensive." CITE Despite the potential expense of separating and burying carbon dioxide below the earth's surface (in the absence of local oil industries prepared to buy it in order to drive more oil out of the ground), such capture methods[8] received substantial research attention during my fieldwork. Articles and announcements made frequent reference to precursor technologies for such geological gas burials, such as natural gas processing and "enhanced hydrocarbon recovery" in which carbon dioxide is pumped underground as a solvent to help drive oil or gas out of rock formations—inadvertently revealing what so many journalists have already discovered: that using CO2 as an oil-harvest-enhancer transforms the value of "storage" from a cost to a paying benefit of geological CCS.

As this section has suggested, CCS economies are grounded in existing schemes of payment for electricity, methane, compressed CO2, construction and maintenance labors, and research and analysis; yet they are also speculative with respect to how technologies will have any given effect on the climate at a given price of operation on a given year. Discussions within the reports cited above share a tendency to present "expectations" (Hansson 2012). The conversations which ensued about whether CCS could receive CEFC funding put the following question at stake: Could the presentation of a technoscientific <u>expectation</u>, especially in the form of a model's outputs, serve as technoscientific <u>evidence</u>?

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[8] Specifically, burial in saline aquifers and depleted hydrocarbon formations.

Carbon Engineering Seeks Inclusion

During winter 2015, three years prior to my full-time fieldwork, I had been sitting at a different trade show called "Disruption and the Energy Industry" in a downtown Sydney conference venue carved out of the posh Sofitel hotel. As the eleventh panelist, the Chief Investment Officer of the Clean Energy Finance Corporation (CEFC) was presenting an orientation to his own organization to an audience of battery, wind, solar, and retail-software industrialists. As he explained, the CEFC, founded in 2012, was an Australian government-owned corporation that distributes investments to "renewable energy, energy efficiency, and low-emissions technologies," and expects returns on its investments. At the end of June 2015, CEFC had supported 89 investments with a total of AU$1.4 billion[9]. The Chief Investment Officer was proud to report that these investments had produced 34 instances of "co-financing" between the CEFC and a private-sector bank. Delineated in a series of small round graphics next to dollar values, the investments parceled out among 60% "renewables," 34% "energy efficiency," and 6% "low-emissions technology;" the last of which was iconized in a graphic of a power plant next to a leaf.

As the presenter described the fund's purview and goals, the aesthetics and staging of his announcements led me to apprehend the CEFC as an investment fund with a mandate to generate green growth. The attendees listening to this presentation alongside me seemed to value their time highly. The battery-manufacturers sharing my table attended selectively and could not spare the time to speak with me, disappearing from the conference venue several speakers before its end. I did not expect to hear of the CEFC again or attend another parallel meeting, as the entry

[9] Approximately then equal to US$1.02 billion. During the hearing in April 2017, one of the presenters reported that AU$5.8 billion (then equivalent to US$4.34 billion) had been invested (Hansard Transcript 2018:17).

fee had been exorbitantly expensive despite my classification as a "small business" absent a discounted "student" category.

After the event, I learned from public journalism that at the inception of the CEFC fund, ,members of the Green Party had negotiated a provision explicitly forbidding the CEFC from investing in nuclear power, nuclear technologies, or carbon capture and storage with geological accumulation (Gantrell 2017, Parkinson 2017). Whether this restriction could be renegotiated was the subject of rumor and possibility around the edges of my early fieldwork, since in February 2017, federal ministers from the Coalition had publicly raised the possibility that the investment mandate of the CEFC be broadened (Vorath 2017). At the time, the CEFC board defined "clean energy" as an energy project that emits 50% or less of the carbon dioxide emissions that, on average, electric grid technologies expended in that year (Hansard Transcript 2018:35); the implication being that "low-emissions" was defined in reference to stationary energy technologies (i.e power plants, turbine farms, and the like) currently in practical use.

During my fieldwork in May 2017, the Malcolm Turbull government proposed a bill for public comment to lift the CCS prohibition (Murphy 2017). Between 8 February 2018 and 8 May 2018, submissions could be made to the Senate (Parliament of Australia 2018). The CCS research industry wanted the prohibition to be lifted, because in its absence CEFC funds could support CCS projects. The bill's proposal prompted the energy-experts who participated in my research to get to work on their common activity of "writing submissions" to government: making evidence-based arguments regarding a particular policy area. Fifteen submissions emerged from this effort—one from the CEFC itself, which reported on its own mandate and operations but did not reveal whether it agreed or disagreed with the proposed broadening. Crucially, some of these parties stood to gain or lose by whether the conceptual difference between “low-emissions” and “clean” could send accessible capital towards or away from their workplaces.

I downloaded the submissions as a zip folder from a government website. Eight parties supported the inclusion of CCS within the CEFC’s scope: the government’s energy department, an oil industry association, a coal industry association, the Australian CCS lobbyist organization, a diversified energy generation firm, and a coal mining firm. Six parties disagreed: two private individuals with energy and emissions expertise; three Australian environmental NGOs, and a left-leaning think tank. The dissent of these critics provides an expansive backdrop of epistemological disagreement and topical divergence from themes raised by the advocates. At the time of the hearing, 18 April 2017, the fifteen authors were grouped into six sets: the think-tank “Australia Institute” spoke alone; then a group of CCS research organizations and advocates spoke together; then a group of environmental NGOs spoke together; then one energy expert (a known renewable energy columnist) spoke individually; then the coal industry organizations who have occasionally sponsored CCS research spoke together; and lastly several government departments or offices, including the CEFC, spoke together. Parties not in attendance included the coal mining firm, the energy generation business, the second individual author, and the oil industry professional association. To analyze these actors, I grouped them into “the critical submitters” and “the advocates,” knowing that this rough and perhaps unfair bifurcation would nevertheless correspond to the dynamics of sets of people speaking together with a shared voice; a procedure built into the hearing process. In what follows, I analyze the arguments they made in the forty-three page single-spaced transcript of the legislative hearing that followed their written submissions, referring to their written pre-hearing materials as needed. I have edited the discourse for brevity.

The critical authors sought to explode the boundaries of “CCS technology” by arguing that it is not one technology, not proven, not existing at scale, or not commercially-scaled in the correct industry of interest (electric power plants) to match with the CEFC’s mandate to make commercially-competitive investments. The CCS concept was considered “a basket” of different technologies; the success of one in one place does not prove anything about the possible success of another in another place. Regarding how it does not exist “at scale,” the critics countered the common claim that between 16 and 22 large CCS projects are currently experiencing success around the world by arguing that only two of them are located at coal-burning power stations, implying that the others’ claims to “success” were unfounded. About being sufficiently commercial to receive CEFC capital and generate a return, the critical authors suggested that the technology was still experimental, or “pre-commercial.” Concerning the possibility that CCS technologies could reduce the emissions of other industries such as steel, gas, ethanol, cement, fertilizers, or urea, these critics argue that such industries exist outside of the CEFC’s mandate and would have to be analyzed separately and decarbonized by some other policy mechanism.

Discussions of the CCS process itself transpired in a tentative mode, as critics occasionally highlighted their own hesitancy to speak about “the engineering” or “the science.” Regarding how CCS technology does not work and is never expected to work, critical points included a lack of global storage space adequate to the volume of carbon dioxide produced by electricity annually; the safety and permanence of storing liquid carbon dioxide below land or water into the geologically-distant future is unproven and cannot be established through just one decade of experiments, if at all; the energy price to compress carbon dioxide and force it into rocks underground is expensive and wasteful, requiring more fuel whenever such a process is used; and that capture processes are incomplete because their rate of capture is too low, they add new toxins to industrial sites, and can omit or worsen the release of other pollutants.

Authors also argued that CCS technologies are not clean, as in practice they do not reduce carbon dioxide emissions but in fact raise them. The authors described themselves as opposed to fossil energy subsidies, characterizing CCS projects in the world today as forms of discursive distraction that enable the continuation of fossil energy infrastructure projects. Writers pointed out that the careless, deceptive, and misleading speech of industrial advocates regarding potential infrastructure projects in economically depressed areas near aging or shuttered coal stations is itself unethical, because it decelerates an “energy transition” and gives false hope to or creates experiential confusion among residents unemployed by coal downturns. Writers also argued that since the CCS industry would inevitably be unable to submit a commercially-competitive project proposal to the CEFC capable of producing returns on investment, the CEFC would increase government waste by using its own administrative resources to review proposals for CCS projects. Implicit within these submissions is the idea that investment in one technology entails the defunding of a potential alternative, and moreover that CCS projects are a financial waste since they have not proved capable of delivering observable emissions reductions. According to this logic, CCS is a distraction from alternative climate mitigation strategies. Implicit in these concerns is the sense that words, projections, and promises are socially consequential in their own right.

Regarding other authorities, such as the International Energy Agency and the Intergovernmental Panel on Climate Change, that do “support” CCS technology in principle, the critical writers argued that such authorities have made mistaken predictions in the past, and are constrained in their recommendations by the data provided by fossil energy industries

The authors I characterize as advocates also shared common messages. They described CCS as “a technology,” a unified thing: “it,” or “the technology,” such that the 16 to 22 different projects underway in the world could stand together as a uniform object from which to extrapolate conclusions, potentialities and futures. While claiming successes from different industries as reflecting upon a unitary “CCS,” they also diverted a sense of its future potential away from energy projects altogether into different applications such as “the hydrogen economy;” thus rhetorically de-linking it from mining industry sponsors. Advocates argued that some industries will be unable to decarbonize by any other means than by burying their emissions underground, and that either they will keep emitting carbon dioxide or they will have to shut down. Furthermore, human life in this logic would become unthinkably bad without crucial industries, and moreover reducing technological complexity is impossible. Finally, CCS is a new industry, advocates wrote: it adds jobs to the economy by, for example, creating a network of pipelines and a need for new facilities to store, manage, and monitor carbon dioxide. It can also stabilize the electric grid and add dispatchable power.

Regarding worldly authorities such as the International Energy Agency and Intergovernmental Panel on Climate Change, the advocates portrayed these as strong supporters of CCS, implying that the CEFC and other merely national (as opposed to international) authorities should fall in line with their judgments. Without the contributions of CCS, the emission reduction pathways that these authorities have modeled will fail to materialize. Because the models and their intergovernmental users have determined that CCS is necessary— indeed, it must receive support—and other governments have financially supported it, the technology has been represented as viable. Just because any one CCS project somewhere in the world has failed to come online as quickly, affordably, or comprehensively as it was planned, does not categorically discredit the technology's promise. Instead, the CEFC will awaken the ability of markets to think on behalf of the global public, and to wisely choose an affordable project through which to realize a decarbonization process.

Tabulated, here is a distilled summary of the critics' logic, counterposed to the advocates' logic:

CCS is many deeply divergent technologies. They have failed in Australia and elsewhere while distracting attention from the continuation of fossil energy regimes. The authorities that corroborate the importance of CCS have been captured by the politics of their own information sources. The CEFC stands at risk of being tapped into by historically-overfunded entities. The electric grid and domestic energy system generally will not be changed by the inclusion of CCS in the CEFC.	CCS technology is similar enough that the success of one of its types in one industry and country proves that a different type may also succeed in a different place. It has succeeded widely until the present moment and has achieved acclaim from universally-recognized authorities. The CEFC has an opportunity to undo its existing ideological provincialism and extend recognition to historically under-addressed technological "options." The electric grid and domestic energy system will benefit from CCS.

Table 4.1 Divergent Epistemological Underpinnings of CEFC Inclusion Commentaries

Advocates advanced an argument particularly salient for the anthropology of liberalism in governance: "technology neutrality," or the notion that the government should not "pick winners in energy technology." Put differently, I provocatively suggest citizens are not allowed to ask their government for particular means by which goals will be achieved. So, entities such as "clean energy finance corporation" or "renewable energy research" would not be able to include or exclude research participants based on which technology they were studying. Instead, the process of thinking about means to ends is restricted to those who are seen as having credentials. This sounds good until one realizes that "what results the technology is expected to deliver" is a presented[10] or projected "fact," which only select actors have the authority to speak for; namely those who are already complicit with existing institutions that stand to lose. Citizens are only allowed to speak of the end, not the means (such as solar PV and windmills.) "Technology neutrality" is an attempt to depoliticize choices among infrastructure: it suggests that only the goal, not the means, is subject to public contestation and opinion-making. Only once the means are set outside the scope of public political conversation are experts, industrialists, and experts hired by industrialists able to then discuss the appropriateness of their particular technological solutions directly with governments. This also appears to be a market-oriented ideology.

Advocates of CCS represented the CEFC as biased because it favored particular technology types.[11] Disregarding the perspective that coal power stations and electricity networks in Australia to which CCS might attach are likely to have been built by Australian states, and then privatized in the 1990s, proponents of "technology neutrality" asserted that renewable energies have received more state financing than CCS, and that the specificity of the CEFC's mandate amounts to a value-laden provincialism that distracts from effective market-based delivery of emissions reductions. In arguing that support for renewables is ideological whereas support for any technology that promises emissions reduction is not, proponents also invoke the phrase "energy diversity;" thereby rhetorically positioning coal technologies as a challenger and renewable energies as an incumbent (which is counterfactual, since state subsidy for carbon energy networks is more than a century old, depending on how the concept of "subsidy" is defined). This "neutrality" concept is (neo)liberal insofar as it suggests that formal

[10] Discussion of a possible shift from "representation" to "presentation" in scientific imagery is made in Daston (2007) and discussed later in this chapter's section "An Economy of Modelers."
[11] The logic evokes contemporary arguments made against affirmative action, in that it presents attempts to remedy historical inequalities as themselves discriminatory.

equality in treatment should be enshrined in policies and procedures, amidst a "market" of 'options' that is purportedly natural and basic, as if infrastructure were not always the product of deliberate human work. In doing so, the "neutrality" concept overlooks the fact of substantively unequal available capital, and allows the formal equality between so-called market options to stand as a social alibi for the emergent order.

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Following these submissions, the Australian government adopted the logic of the advocates as its own. On 30 May 2017, the Energy Minister issued a media release pointing to the number of CCS projects around the world as proof of the technology's viability: "CCS is a proven technology being deployed globally with 17 large-scale commercial CCS facilities already in operation." In addition, the media release repeated three points of logic from the advocacy arguments. First, it pointed to the IEA and IPCC as two authorities that have "acclaimed" CCS as "critical"; second, it suggested how CCS could possibly be used in the future in non-power industrial sectors such as steelmaking (i.e., that its use could be expanded); and finally, it described how the inclusion of CCS would advance the CEFC fund's business imperatives, such as curtailing carbon dioxide "at lowest cost," with "reduce[d] risk for potential investors" (Frydenberg 2017). In contrast, the Australian government rejected the critics' proposed rhetorical revisions for what should be considered a possible emissions reduction. Following Timothy Choy's concept of "articulated knowledges" (2005), it appears that the knowledge of the advocating writers was "articulated" and taken up as authoritative, whereas t9he knowledge of the critical writers was not regarded as having expert status (Choy 2005). During the hearing, even though individual parliamentarians asked questions pertaining to the
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lines of information and advocacy that witnesses articulated, ultimately the government appeared unable to differentiate between how industrialists labeled a particular technology project in their own technological fields and expectations for how the project would actually perform in the world. Ultimately, differentiation disappeared between how industrialists label their own technology projects, and how the technology project would be expected to perform in the world. Or alternatively, perhaps if the government was aware, it did not ultimately mind that the label of "clean" was irrelevant to these works.

For CCS advocates, providing evidence of efficacy required reification of "the technology" that said evidence is meant to speak to; whereas critics attempted unsuccessfully to take that reification apart, suggesting that success in a natural gas processing facility had no bearing on potential success in an electric power facility. If critics could succeed in dis-integrating the object of CCS, in doing so they would also dismantle the logical underpinnings of the technology's ostensible success, replacing this seamless record with isolated, incommensurable, unrelated events. As Leo Marx (2010) writes, "technology" itself is a "hazardous concept;" a misplaced reification and attribution of the creativity of multitudes:

> Consider, once again, automotive technology. Its defining, indispensable material core was of course the internal combustion engine, plus -naturally- the rest of the automobile chassis. But surely the technology also includes the mechanized assembly lines, the factories, the skilled workforce, the automotive engineers, the engineering knowledge, the corporate structures including the stockholders and the huge capital investments, and the networks of dealers and repair facilities. Where, then, do we draw the boundary between the system and the rest of the society and culture? Do we include among the facets of automotive technology the road-building and maintenance systems, the trucking industry, the indispensable feeder industries - glass, rubber, steel, aluminum, plastics, etc.? What about the mines that provide the raw materials? (Marx 2010:575)

Just as Marx unbounds the supposed object of a technology analytically, so the critics sought to disarticulate CCS in a real political contest. Yet CCS's diffuse industrial entanglements also offered opportunities to evoke the multitudes, “the rest of the society and culture” that would be excluded by a narrowly scaled renewable energy fund.

An Economy of Modelers

This section will analyze the cultural logics by which making predictions from models and simulations has become normalized within carbon engineering's institutional homes—as evidenced in the intellectual approach of a favored authority cited by CCS reports: the Intergovernmental Panel on Climate Change (IPCC).

As the chair of an academic engineering department told me in 2017: “We hired two top professors from Manchester here. They work in the grids area. With big problems, you *model* them.” In an engineering school, to extend one's thinking over vast spaces and times was considered normal if it could be achieved through modeling technologies. Yet claims that seemed larger in temporal scope than evidence could support were simultaneously suspect, since once the model itself was operationalized as evidence, observers could point out that it was a fabrication. For instance: in Golden Beach, Victoria, one of my research participants argued that by attempting to make truth-claims about the deep future, experts presented themselves as non-evidence-based: “60,000 years? Then it turns to rock? It is a new science. They discredited themselves.” Insofar as predictions about carbon engineering's efficacies transcend direct experience, this duality—between the model-mediated nature of carbon engineering knowledge as both a sign of expertise and its disqualification—constrained the possible representations of carbon engineering.

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Jasper had been scheduled to speak immediately after a presentation on "Commercialisation of Emerging Post-Quantum Energy Systems." I met him at a major energy trade show; attendance was free for attendees, who were presumably subsidized by the advertising fees of booth-holders in the exhibition hall nearby. The slides behind Jasper's podium displayed red apples, oranges, and green apples lined up at a market. With these images, he sought to convey that although renewable energy technologies provide electricity more affordably, it would still be wrong to compare types of power generation technology on the basis of "levelized cost of electricity" (LCOE). Jasper proved his point via a breakdown of costs on a consumer's electricity bill, portrayed on another slide, and gestured to the additional listed charges. The electricity network must be treated "as a machine," not only "as a market," Jasper contended. This machine could not be known—or optimized—by the cost of electricity alone, he specified. Doing so would challenge or refute the physical and engineering laws that bound it together. Through modeling, Jasper had found a way of thinking of "the cost of the machine." By considering how the modeling figured in his thinking and work, we can locate it in relation to the notion of "being on a transition pathway" as well as examine its discursive currency vis-à-vis the social categorization of carbon engineering.

The modeling Jasper presented had been prepared by several companies whose logos featured on the slide. As I will explain below, the slide was an intermediate product in a process of producing representations of a particular type. A representative from one of the company sponsors sat in the back right of the room, lounging slightly against the movable fabric wall beside his computer briefcase. I discovered his presence some time later when I asked a question about what, exactly, had been included in the model; Jasper summoned him to respond, and he duly opened the computer from his case in order to address my questions. Later, I would learn that these two professionals lived in different cities. Since I had already heard of Jasper, my core mission at the trade show was to get a face-to-face encounter with him that I could later try to parlay into an individual research interview; I succeeded in obtaining his business card. Later, as I roamed the exhibit halls, I caught a glimpse of Jasper and his consultant sitting together, sipping coffee under a bamboo screen in the foyer of the trade show; perhaps brainstorming about future modeling projects yet to be undertaken.

As scientists orient toward businesses, their imagery changes. In the conclusion of Daston and Galison's germinal work, *Objectivity*, Daston contemplates a possible shift from "representation" to "presentation" within the sciences at their time of writing. While she glosses representation as "fidelity to nature," and characterizes three ways it has manifested over time (truth-to-nature, mechanical objectivity and trained judgement), she summarizes "presentation" as "fusing artifactual and natural" (2007:413). The ideal of the scientist as conveying something unmediated by representation is at risk of being passed by. Daston suggests: "Simulations, artificial color, rescaling, virtual cutting—in all of these and other ways, the image itself no longer is held to be a copy" (2007:413). It is precisely a shift from representation to presentation that Jasper appeared to suggest in his claim that all of the electric grid could be collectively considered and optimized as one "machine," portrayed within his colleague's computer program, and then intervened upon with carbon engineering, in order to study the "costs"[12] that would emerge.

[12] Attempts to ask who would pay these costs were met by the exclamation that "We all do!"

Several months later, I met Jasper at his office for a research interview. Seated across from him at a small round table near a glass wall, I fired off my questions: How had he come to know about CCS technologies? What had been his own professional history, in its intersection with the growth of CCS? To my amusement, our interview was overseen by a row of gilded and red-colored toys arranged atop his bookshelves. I have seen those toys in other offices as well; souvenirs of business travel, I assume. Cats holding a paw in the air, in shelving spaces that held fewer books than binders and reports.

In the mid-2000s, Jasper observed a constellation of CCS projects from within a major mining company that produced coal, minerals, iron and aluminium ore, and diamonds. He originally trained in radiation physics, and began his career as a state regulator and eventually a federal regulator for uranium mining. Eight years later, he "jumped the fence" for work in environmental health and safety at an actual uranium mine, shifting into the energy business of that mining company. At this time—around 2006—he first heard of CCS. In Jasper's new role at the mining company, his work took on three new dimensions: studying and understanding the details of Australia's climate policy (specifically its mechanisms, definitions, and applications); bringing his company's position to the government's awareness; and writing "product stewardship strategies" for coal and uranium.

What did it mean to strategize a product's stewardship? To be a steward of coal required thinking about the potential loss of its "political capital." This loss would become visible and calculable as it manifests in moments of social decision-making; decisions that would not prove favorable for the resource miners. For instance, loss would become evident in moments in which the company could not hire the employees it needed. "It's difficult to access talent. Loss of social license, loss of political capital, at the end of the day, dramatically increases your cost of production." As such, do companies want to be "exposed" to coal? How do they manage their "coal exposure"? Especially since, "just as governments are lobbied, these large companies are lobbied," by their shareholders? Such liabilities—and socio-political contagions—were key themes of Jasper's work.

As he recalled the early investment of a collective two or three billion dollars into CCS programs, Jasper revealed that he came to know by around 2007 to 2009 that the expectations embodied in the "CCS Flagships" investment policy—to fund several power station or equivalent projects—would not be met, because the price of constructing each would be higher than anticipated. The facilities were not only expensive, but also ambiguously desired. "So, they're not pandas," he noted. "They are like some rare little frog sitting in a swamp somewhere. But they are actually important for the ecosystem of the swamp, you know what I mean?" By invoking the image of a "rare little frog," Jasper demonstrated his skill in appealing to a sense of rational environmentalism. He implies that just as only a thoughtful, aware, educated environmentalist could appreciate a frog, only a careful and methodical thinker would support CCS technology. But just as even the most immature and underreflective environmentalist would love a panda, anyone would endorse a solar panel or a wind turbine. Like a "rare little frog," CCS projects may be underappreciated and devalued by their own investors.

Historically, this actually happened, as Jasper remembered. Two mining companies had spoken up at the time—the late 2000s: "Look, we're going to have to shut this thing down, you know? Because there is no way we can make any money out of this. It's charity, and we're not charities." Jasper is not surprised by their reaction: "The coal companies don't know anything about power generation, or carbon capture and storage technology." With this claim, Jasper categorizes industries by their type of workforce. Whose industry is CCS part of? I ask. "It's its own industry. If it belongs to anyone, it belongs to oil and gas, because they understand how fluids behave in the subsurface. They re-inject regularly into the subsurface to dispose of fluids they produce with oil and gas that have no saleable value." For Jasper, CCS is part of the oil and gas community because it must be done by those, workers who have the ability for it.

At the time of our meeting, Jasper's nine employees are located on three continents. He seems more comfortable attributing agency to corporations and types of industry than he does in positioning people as the ultimate agents or characters who could steer the former. I stop recording at least once during our hour and twenty minutes so that Jasper can take a phone call and direct someone to buy a plane ticket and go somewhere; he then returns to our meeting. Jasper's daily life at work, as recounted to me, entails making presentations and preparing proposals for consulting work that his organization undertakes. For example, a government that views CCS as important approached his organization,with a request for knowledge about "what a regulatory regime for storage of CO_2 should comprise, essentially." In particular, they inquired about conceivable kinds of long-term liability and regulatory structures. Jasper's team works to prepare this type of advice, and collects fees for their service. In a sense, then, I realize while composing this ethnographic portrait, Jasper's position in an economy of expert advice may not even be so different from that of the modeling expert who helped him explain his presentation—and more specifically his depiction of the entire "machine" of the electricity network—to me and to the trade show audience. Ultimately Jasper advises people who would hire him and his team.

In this capacity, he speaks with authority about uranium radiation effects, the costs of the electricity network, and the political and commercial hazards of "coal exposure."

Metonymic Narratives

Rather than changing the answer to the question of whether the climate is changing,[13] the CCS research industry in 2017 was trying to change the question itself—from "How can we have more renewable energy?" to "How can we have more low-emissions energy and low-emissions industry?" Their expansion of the CEFC's mandate from what was effectively a niche for renewable energy to a more expansive, goal-driven initiative for "technology-neutral low-emissions" can be understood against this chapter's opening anecdote in which a technology's representation as "clean" or "responsible" is a means of access to finance.

Advocates' definitions of "clean" were partial, since mercury, sulphur, nitrous oxides, and particulates (Freese 2003) are emitted from "all but the most modern" coal plants (Economist 2015). What's more, mines and industrial installations inflict diverse injuries upon their neighbors, including noise, particulate matter, blast vibrations that crack the walls of houses, as well as disrespectful or frightening conduct of security and public relations officers (Munro 2012). Yet a market was in the process of being formed: it was what Fairhead, Leach, and Scoones (2012:242) characterize as "an economy of repair":

> It is the repair of a damaged nature, and efforts to price the downside of growth, that have brought into being and enhanced the value of commodities such as carbon, biofuels and offsets of all kinds (whether biodiversity, species or climate). The economy of repair has been smuggled in within the rubric of 'sustainability,' but its logic is clear: that unsustainable use 'here' can be repaired by sustainable practices 'there,' with one nature subordinated to the other. Once this logic of

[13] . . . As a strict analogy to "Merchants of Doubt" by Naomi Oreskes would have it.

> repair is grasped, so a new interplay can be discerned which is doubly valuing nature: for its use and for its repair. The damage inflicted by economic growth generating unsustainable resources thus creates the basis for the new growth economy of repair.

These authors recommend that scholars of "green" value extraction analyze the interaction between science-policy concepts that act as discursive frames and the economies that they enable. The discursive frames in this case are "low-emissions" and "technology neutrality." Their uncertain meanings have not prevented but rather enabled market-making for taxpayer-funded low-interest capital by coal technology researchers, precisely because they pledge to finance to potentially any project that persuasively describes its likely efficacies. On the construction of such a discursive "architecture," Fairhead et al. (Ibid:2012) argue that:

> …a peculiar feature of the financialized modern economy is that the value of the commodity is constructed and co-produced within the architecture of its financialization – in interaction with the international institutions apparently governing them and the policies of the state. Sociologists have observed this, for instance, in financial derivatives markets (MacKenzie et al. 2007), but new green markets also offer perfect exemplars (Sullivan 2011). Those exerting power over the markets thus play them with loaded dice.

Here, loading the dice, refers to the ability to shift the terms of a conversation such that an original goal can be dislocated in service of a purportedly broader ideal that serves the financial interests of those who reset the terms.

Reasoning from the discourses raised in the submissions to the Australian government, as well as from the ethnographic experiences that frame their significance, I conclude with a recipe that I believe advocates of CCS follow as they build their discursive frame:

1. Set the problem as atmospheric carbon dioxide *only*. Ignore concerns such as "energy justice;" the social efficacies of propaganda or false hopes; and citizens' wishes to participate in energy and emissions reduction projects in any other mode than as mere

consumers. Relatedly, set the problem in terms of a set of industrial needs that are so vast, expansive, and arguably private—if they correspond to private industrial facilities whose "problems" never meet the public eye—such that an extensive armature of, as Shapin and Shaffer (1985) term them, literary technologies (virtual witnessing), material technologies (demonstrable infrastructure), and social technologies (the community of experimenters) are required to make an argument that this problem does in fact exist yet may be addressed.

2. Set up the technological solution to match the problem of carbon dioxide. Define "clean" or "low emissions" so that the term describes what happens in part of the plant, part of the time, to part of the pollution, considering only one of the possible baselines that could exist (i.e., comparing to a baseline that represents a specific kind power plant that may have become obsolete in the country in which funding is sought.)

I call this recipe "**industrial metonymy**." Metonymy is a poetic figure that refers to the substitution of one thing's name with another: "A metonymy (from the Greek for *change of name*) is a figure in which the name of one thing is used for another to which it has a relationship of contiguity, as the use of 'crown' to mean the king" (Makaryk 1993:590). In my use of the term, part stands in for whole. With respect to how CO2 stands in place of all emissions, and one module stands in place of an entire facility, the part-for-whole substitution is evident; but the temporal dimension is also key—for instance, regarding how carbon separation and storage machines may operate only part of the time, or will eventually operate in the future, or will operate but then pipe in to an oilfield and eventually bubble back up. An industrial pollution control device that runs part of the time, removes part of the pollution (that is, CO2), and has emissions control technology on only part of the site becomes conceivable as “clean.” In a representational reconfiguration with financial effects—not only for carbon research industrialists personally but also for their colleagues who may benefit from CCS becoming “more proven” or “more common”—the speaking strategy I call industrial metonymy renames a site a “low-emissions technology demonstration center.”

Like any other industrial facility, CCS projects omit greenhouse gasses to the atmosphere. If enabling newly-built extractive operations, such as the Gorgon Project (or Coal-to Hydrogen (Commonwealth of Australia 2019), the emissions of which are only partially or not at all compensated for (because these projects may never have their CCS components actually turned on), CCS would allow more emissions than would have otherwise occurred in that site, and hence is not “emissions-mitigating” or “emissions-reducing.” Even if a project operator institution describes its technology as “zero-emissions” or “emissions-neutral,” a determined critic would be able to locate some procedure that had not been accounted for within the framed set of processes whose emissions were zero, or to critique whether the “offset” procedure had functioned as described by its operators, or both. When an industrial project of any type is newly built, the question of whether it has “reduced emissions” can only be answered by a comparison to something else—the spectral and hypothetical alternative—“unreduced” or “normal emissions” infrastructure. This means that the very label of “lower emissions” is itself built upon a foundation of expert judgment regarding how that alternative should be taken up. Does a project “mitigate” or “reduce” emissions compared to 1990s technology? Or 2010s? If the expert is situated within a governmental “Office of Fossil Energy,” then would that person hold expert awareness of “current” wind technology as well as of “current” carbon technology?

More precisely, carbon engineering only reduces the carbon spewing into the sky under certain conditions, such as: it is applied to *existing* infrastructure, *comprehensively* rather partially, and then actually *turned on*—rather than applied to newly-built infrastructure that would not have been constructed otherwise, and then rarely or partially turned on.

Forgetting is a social process (Auge 2004). Coal becomes clean through industrial metonymy: several dimensions of partial "cleanliness" are layered on top of each other; the partial nature of each dimension is socially forgotten; and the single phrases "low emissions" or "clean technology" stand ready for use and repetition.

Repeated, Reinterpreted

The willingness of Australians to repeat the metonymic statement that CCS is "clean technology" and to agree that "technology neutrality" is a desirable goal for energy policy is not unlimited. I raise here one account of whether and how "technology neutrality in energy policy" and the CEFC inclusion made conceptual sense to a neighbor of an Australian CCS project.

I met Rosemary in her "shack," as she called it—her refuge on a tiny plot of land far from Melbourne. She retreated to the shack whenever she wanted to focus on her own creative practice, away from the demands of family and work. Rosemary holds a PhD and typically supervises ten to twelve PhD students in a major university, although she recalls a moment in her career in which "all of us were offered redundancies because they didn't consider our work to be 'research.'" I asked Rosemary to tell me the story of how the CCS research industry had arrived to Golden Beach:

> Historic events weren't visible to me. The life-saving club patrolling the beach, carrying out a seismic survey. Then I saw—I found—a leaflet dropped—inviting me to a barbeque. IFS—a group who were contracted by CarbonNet.

> I had suffered *incredible* seismic shocks in my shack. 500 metres—a series of mini-earthquakes. The sonic boom was quite extraordinary. When I …Don't sell your soul for a sausage. To test the bedrock for its so-called impermeability. So that CO2 can be stored. At least a hundred kilometers of pipeline. The whole thing was a very suspect ploy, to perpetuate a very inefficient production of fuel, massive amounts of water vapor. This is a ploy partly supported by Labor state government, worried about maintaining employment in the Latrobe Valley. And they wanted Loy Yang to be retrofitted. Part of the driver is to dump CO2 waste off-grid, recovery of some oil from spent wells. Trying to prove this is economical. My perception is that "impermeable" is a very vague concept. Decades, or millenia, from now, it could have ecocidal effects.
>
> There has been a vote to put through the legislation to have it qualify as a *sustainable* process—effectively that means brown coal. Enable CCS to get big subsidies, to enable it.

Regarding the CEFC:

> A perverse and cynical maneuver of rhetoric, to greenwash what is still a fossil fuel industry. To try to retrospectively change legislation. $1.4 billion already spent on the CarbonNet project, and yet this legislation that is rooted. I have to write some letters to senators to beg them to vote against it. Were it to be green and go ahead, more money. It will suck the money away from these projects.
>
> 'Technological neutrality,' this reminds me of *Animal Farm*. We know it is a shitty source. Ideologically neutral, we shouldn't be emotional. The <u>mendacity</u> of the whole thing. Storage itself is a danger. There are hunters who rove the area. What happens if bullets pierce the pipeline and it goes into the groundwater? A sane person looks at the dangers, would not say 'neutral.' It has intrinsic risks.

Rosemary insists that being "neutral" about "known" and "intrinsic" dangers is an act of forgetting that she refuses to perform. To disregard anecdotal risks would be a reduction of logic, not its expansion.

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As I have argued, the facts that made CCS compelling to Matt, Jasper, and some parties to CEFC governance are products of modeling and projection—as well as the models themselves—rather than of direct observations. Yet the very applicability of modeling and projection are contested. Metonymic descriptions attempt to restrict where carbon engineering's
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efficacy should be seen, with respect to place, time, and type of pollution; yet the actual efficacies of proposed carbon engineering plants in all ways "leak" around the edges of these representations. This kind of contestation could not be described as "a new kind" of politics (Clark 2014). Instead, it is just another politics of conflicting assessments of efficacy underpinned by discordant epistemologies. To some extent, many sciences establish a part-for-whole logic—this has been intrinsic to actor-network theory's notion of the displacement, in which the work of the scientist is to route something through a laboratory space, which then unlocks transformative power that can be wielded over a larger topography (Callon 1999; Latour 1993, 1999). However, the inclusion conversation did not actually move anything through any laboratory, apart from financial aid. What was at stake was conceptual participation in the realm of "low-emissions." Contra Clark (2014), actual states of geological systems are not transparently at stake in these politics—merely the funding of alternative research industries are.

Common forms of public communication present CCS as a response to the threat of carbon's climate-changing effects—as if it were a technology intervening upon material, physical relationships. However, these could equally well present CCS as a response to the *threat of decarbonization itself*. In this conclusion, I argue that academic conceptualizations of CCS need to catch up with the awareness already held by actors in the scene: that CCS responds not to climate, but to decarbonization as a social project. As another resident of the town of Golden Beach expressed, it is possible to support action on CCS even while opposing action to address climate change: "Friends I used to live with in Caufield: they are climate deniers. They are pro-CCS, as it will allow the political issues to go away." Accordingly, academic understandings of carbon engineering must conceptualize it as something already known to actors as a sociotechnical response to a sociopolitical issue, more so than a material one.

In what sense can "decarbonization itself" be a threat? Decarbonization, insofar as it rearranges what counts as wealth and what financial opportunities may be realized, may be experienced as a threat by any actors who have successfully materialized and maintained wealth in a prior, carbon-intensive economy that is becoming newly subject to re-evaluation in ways that cannot be centrally controlled. Worth noting here is an obvious point of information that flickered just around the edges of conversations about the importance of carbon-managing technologies, yet neither my interlocutors nor I usually referenced explicitly. This point was that CCS maintains the value of existing "assets," where "assets" refers to either geological deposits of yet-unmined fuels, or built objects such as industrial pipelines and refineries. To acknowledge that CCS "maintains the value of existing assets" is to acknowledge that decarbonization *without* CCS is a social process that degrades, rearranges, or otherwise calls into question the "value of existing assets." By the publication time (2012) of one of the few edited volumes of academic CCS-related scholarship, it had become obvious that widespread socio-political reconsideration of whether a refinery was a useful piece of property to own, or whether some grassy field should become a mine—in a word, "decarbonization" as a sociopolitical project —was "clearly a threat to many established practices and institutions" (Markusson, Shackley, and Evar 2012:5).

CCS, then, can serve as a response, not to the threat of carbon itself, but instead to the threat of decarbonization as felt by "a range of actors throughout society" particularly in the wealthier areas of the world (Ibid 2012:5). CCS can absorb—through technological installation or its potential—sociopolitical critiques of environmental harm without allowing them to damage existing infrastructure's financial value. What the edited volume seems to suggest by pointing out that "global warming will impact on the global south more than the industrialized north, which is the source of the lion's share of the emissions" (5) is that the effects of decarbonization will be felt more intensively by wealthier people and places, while the effects of climate change will be felt more intensively by less wealthy people and places. As such, decarbonization as a threat affects different populations than climate change as a threat; and CCS may become attractive because it serves to produce a survival amidst the first (i.e., decarbonization), even though CCS-related communications may emphasize its ability to produce a survival against the second (i.e., climate change).

Having established that the threat of decarbonization and the threat of climate change are located and felt differently, we can re-evaluate what happens when rhetorics of carbon engineering blur these two modes of survival together. Survival-amidst-climate-change attracts massive social interest, at least on an emotional and imaginative level, if not in widespread change to daily life practice. Survival-amidst-decarbonization is slightly distasteful, as it is primarily of interest to those who hold properties that decarbonization threatens. It is both a truisim and also a point of advertisement that:

> Among technical decarbonisation options, CCS offers the unique prospect of reconciling substantial climate change mitigation with the continued use of fossil fuels. This would preserve the economic value of the existing fossil fuel regime, with its capital assets, skills, and institutions—a fact that helps in explaining the wide appeal of CCS and its rapid rise on climate and energy policy agendas" (Markusson, Shackley, and Evar 2012:2).

In saying so, these authors naturalize the assumption that policy agendas are set by wealthy or otherwise powerful agents; although I do not disagree, I instead speculate about the mechanism for this rise. What gets lost when CCS is symbolically linked to survival-amidst-climate-change rather than survival-amidst-decarbonization is the fact that continued existence of carbon-intensive industries is a more precise and less charismatic conceptual range for "survival;" yet even as such, it may receive a substantial dose of the social interest placed on the more inclusive and expansive conceptual range.

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This chapter has observed how the social authority to speak, not only for the properties of a technological "fix," but also for what counts as a problem to be addressed, is gained and stabilized. By describing the making of the Australian Clean Energy Finance Corporation's 2017 CCS inclusion policy, it has articulated the neologism "industrial metonymy." In the inclusion decision, a fusion of scientific, industrial, and governmental authority can be observed that considers carbon dioxide, not other pollutants nor modes of living and working, to be the core problem of climate change. Ethnographic witnessing of the CEFC inclusion policy's process renders visible Australian configurations of knowledge, ethics, and political authority within or around representation of energy and emissions technology.

Now that the importance of collective social thinking regarding the nature of "cleanliness" in technoscience has been established, future chapters will turn away from the analysis of single concepts that are at play in social life (and how to conceptualize their effects), and instead analyze what is an ethics code and who does it apply to (Chapter 3), and how institutional delimitations setting a "box" for knowledge and responsibility can serve as a precondition for engineering thinking (Chapter 4). Ultimately these add to an argument that for Australians, the structure of businesses and certification regimes have been more consequential than any individual person's beliefs have been, for the practice of "responsibility" in carbon engineering.
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CHAPTER 3: CODIFIED ETHICS

How Australian Engineering's Professional Ethics Codes Configure the Boundaries of Practice, Person, and Efficacy

> All members will undoubtedly agree that the most important precept is contained in the preamble, in which members of The Institution are enjoined to conform with the spirit of the Code and in addition, to comport themselves at all times with dignity and propriety.
>
> —Journal of the Institution of Engineers, June 1959

> The melding of ethics and professionalism has significantly contributed to the development of engineering ethics concepts.
>
> —Herkert 2009

As Chapters 2, 4, and Chapter 1's definitional note regarding "responsibility" establish, the full conceptual contours of "responsible engineering" are larger than those of any actual or potential "Code of Ethics." These contours could range from financialized and highly public claims to cleanliness (Ch. 2), to quiet, ordinary experiences of deliberate downscaling of what is known about and cared about within a work project (Ch. 4). This third chapter asks why and how the engineering association has taken on its current stance regarding practitioner ethics. By studying historical ethics codes and the moments and imaginaries by which they have been mobilized, it contributes to a larger investigation of the ways that engineers can conceptualize their work as responsible, even while they unleash technologies that their fellow citizens may understand to be destructive.[1] From the point of view of these ethics codes[2] and the technical

[1] For example, the first research participant I met who was pursuing the CPEng credential, "Chartered Professional Engineer," via the engineering association under study here was concurrently employed in coal seam gas (CSG) engineering in Queensland. Public mobilization and rejection of unconventional gas mining reveals that the heights of engineering professionalism can be achieved by those employed within "a matter of national and international controversy" (de Rijke 2013).

[2] The 1919 ethics code was sourced from Corbett (1973). The 1926 code was found in the Quarterly Bulletin. The 1950, 1959, and 1964 codes were found in the Journal of the Institution. The 1972 and 1979 codes were found in the personal records of a former member who emailed

workers whom they regulate, how has "ethics" been conceptualized such that developing contested technology can be seen as ethical and responsible work? How have more-than-a-century of specific institutional events configured the aspirations and reasoning of the engineering association's current participants?

By means of a careful study of ethics codes contents since 1919, leavened with recent ethnographic information, the chapter argues that the process of codifying practitioner ethics is related to the process of using formal education and credentials as a basis for inclusion in or exclusion from "engineering." An alignment of ethical excellence with formalized participation has taken place, but as the end of the chapter shows, it can also break down.

An "Ethics Lens"

Applied social scientists have mentioned that carbon capture and storage can be seen "through an ethics lens" (Medvecky et al. 2014). These authors, a foil for this chapter, explain their analytical perspective as follows:

> In this paper, we take a universal point of view with regard to ethics. That is to say, we start from the position that no ethical principle can be justified based on the self-interest of any particular or sectional group alone [. . .] what is most interesting in this paper is the opportunity to examine the relationship between the more theoretical or meta ethical issues and how they relate to the more practical or normative aspects of CCS. This is because the theoretical and practical aspects of the way we respond to a technology like CCS are inextricably linked. (Medvecky et al. 2014:1113).

Confident in their abilities to notice "the" issues raised by a technology, these particular authors aspire "to highlight and review some of the most critical applied ethical issues that are associated with the use of CCS" (1113), calling this the use of a "lens." They assert that their act of pointing

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them to me, and the 2000 and 2010 ethics codes were found online at the Center for the Study of Ethics in Professions.

attention to “the most critical” issues is a completely different project than “recommend[ing] a particular moral position to the reader” (1113). This assumption—that naming the “most critical” issues is not the same as making a moral recommendation—is not one I share[3]. Instead of looking *through* the “ethics lens” from an aspirationally “universal” point of view in the way that Medvecky et al. are role modeling, I look instead *at* that lens, that attitude under which naming the “most critical” issues is not in itself moral. In so doing, I suggest that the specific institutional ways that Australian engineering ethics have been framed, established, and enacted (Carr 2010)—at least partially via ethics codes such as the ones examined here—creates the conditions under which applied scientists of CCS have the authority to simultaneously define “most critical” while disavowing the ethical nature of that definitional act. I assume it also contributes to the conditions in which a CCS engineer can consider herself to be behaving in a totally responsible way, without any cognitive dissonance, regardless of the contested desirability of the technologies brought into existence (Latour 1996) by her actions.

Considering the ethics codes, let us provisionally assume that they form “the lens” within a certain population’s eyeglasses, defining the contours of what is and is not an ethico-moral act for the people who use them and live with them. That is a large assumption since it disattends to the strong possibility that the ethics codes are merely bureaucratic artifacts that do not feature in practices or decision making (being, therefore, like reading glasses left in a drawer by people who find other ways to scrutinize texts in moments of necessity.) However, the codes are this chapter’s most central historical record, and their affordances, once they can be assumed to indeed have a social life, are its central interest. If we look at this “lens,” this set of codes, that Australian engineers are assumed to have been looking through, what do we see?

[3] Arguably, it is a claim to authority—to knowledge-based authority regarding morality itself.

I contend that for most of the history of the engineering ethics codes, they show themselves as having been designed to protect not societies and environments from practitioners, but practitioners from their would-be peers. I contend that the process of establishing an ethics code relates to the process of firming up the definition of “engineer.” Both are, over their longer history in Australia, exclusionary projects by which a small subset of a practitioner community keeps other practitioners away from claiming the same purview of expertise and knowledge-based authority. Social scientists have long known that distinctions between categories of persons are important locations of boundary work (Pereira 2018; Gieryn 1983). Empirical study of the engineer-scientist boundary is set aside within another chapter’s discussion of the “research engineer.” This chapter discusses the social processes excluding certain people—arguably also experts regarding devices, infrastructure, and technological materials—from the category of “engineer,” claiming that codification of ethics is one of these processes.

By considering code content as well as the roads not traveled in terms of former institutional structures for engineering collectivities, I argue that the codes create an exclusionary, intramural form of “professional” solidarity by means of four explorations meant to explode the hermetic, impermeable borders of a single “ethics code” document and regain it as a living object that condenses and attracts people’s purposeful concerns and hopes. These codes become part of a larger story once they are shown to be entangled with (1) the changing borderlands of who counts as an engineer and why, conveyed by archived engineering journals, magazines, and insider essays, ethnographic information, and relevant historical works; (2) their own literal and thematic content in historical motion; (3) the aspirations of a few people who wanted to use the codes for diverging ends; and (4) a moment of fracture when a historically-uninvited guest—environmental politics—sought to force an entry and redefine ethics as something other than the private property of elites. I raise the possibility that the ethics code both frames (as would a "lens") "ethics" as conceptualized and experienced by some population of engineers as well as playing a key role within a process of class conflict in the vicinity of technological work and claims to expertise.

Conceptually Narrowing "Engineer"

"We don't do unfriendly design," he said. "I've never seen those projects in the shop." By unfriendly design, Lachlan meant park benches spliced with metal ridges to prevent people from lying down; raised flowerbeds studded with bolts to prevent passersby from leaning or loitering too long; and other forms of metal rails or guards to constrain the use of public space. Lachlan, more than six feet tall, has substantial arm and leg muscles and tawny hair oxidized to blond ringlets by the sun. He has traveled to Melbourne from a small town in northern New South Wales in search of a better pay rate. We are eating at an outdoor table within walking distance from the indoor rock-climbing gym in Melbourne. Our membership in the same Meetup group for would-be climbers has brought us together.

Very quickly, Lachlan has been able to understand that I am curious about what counts as responsible engineering, and he patiently accepts my unconventional interest in hearing the ways his shop uses drawings and designs to produce metal components, sending me some of those diagrams as well as the syllabi he learned from during parts of his education. More conventionally, he has also told stories I am sure he has told to other lunch companions before about how his clothes and pant legs are at constant risk of being burned and melted away by molten metal that is the substrate of his craft. He eventually shows me the website of his former workplace in his hometown, where he is on leave in order to explore Melbourne and vicinities.

This website includes a man holding a mask to his face with bare hands while raising sparks from a piece of metal in front of him. Lachlan laughs about how the picture on the website actually depicts an unsafe work practice: the tattooed arms wear no gloves. The photographer, whom Lachlan knows, was mainly trying to capture a beautiful image with the sparks. It is only because the company is in a small town and already knows most of their customers, he speculates, that they can not only use this picture demonstrating inadequate personal protective equipment, but also name their business "Merriwa Metals Engineering,"[4] while not being actual engineers.

Lachlan is a "tradie," a tradesperson—specifically a "boilermaker," who proudly enjoys knowing that his benches have been installed in public spaces throughout Melbourne's geographic region. To me, the fact that he is a boilermaker makes him a slightly legendary character, since engineering historians and engineering studies sources had repeatedly spoken of how the emergent danger of steam boiler explosions was a key reason that engineering knowledge "first" needed to be subject to science-based rules and codes (e.g., Yates and Murphy 2019). Obviously, Lachlan holds practical technological knowledge, but just as he believes his small-town workplace ought not to label itself as an "engineering" firm, he does not identify himself as an engineer.[5] Indeed, when my fieldwork ended and I returned to the webpage in order to capture the image described above, I find that since our 2017 climbs and conversations, the company has renamed itself "Merriwa Metals Fabrication" instead of "Merriwa Metals

[4] Exact company name withheld.
[5] During the first day that we met, I recorded in my fieldnotes that he called himself a "metal fabrication engineer." However, as our friendship grew over time, that designation was quickly dropped, and it seemed to be something he could tell a stranger, perhaps in the mode of presenting himself in his best possible light, but not necessarily as a title he personally identified with.

Engineering," while keeping the same logo and visual design. Their former name is traceable, but buried in a testimonial from local real estate developers about years of trustworthy and dependable service. Perhaps upon his return from the city and subsequent travels overseas, Lachlan told them that if they did not have engineering degrees from universities, they did not have a right to the title they had claimed.

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Contemporary urban eastern Australian usage of the term "engineering" typically refers to something that requires accredited four-year college degrees as well as accredited forms of on-the-job training. It also has particular racial and gendered overtones. But Lachlan and his collaborators would not be part of this conceptualization of expert technological work, as I was constantly reminded while investigating what my interlocutors considered part of "engineering education." For example, upon hearing that the "Electrical Trades Union" had developed a Centre of Excellence in electrical education—like a trade school, but meant to be staffed and equipped to high standards—that I was about to go visit, a volunteer leader of the electrical engineering group of the professional association sniffed and rolled his eyes. The differentiation of electrical tradespeople from electrical engineering, metal tradespeople from civil-structural engineering, etc., was an ongoing matter of concern for writers of "letters to the editor" in the engineering magazine and professional journal that I was reviewing at the state library during my working hours. I had decided to review this publication set because I had requested access to the archives of the professional association in order to study their prior ethics codes and public policy statements regarding responsible energy technology, but that access had been denied.[6]

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[6] The association's response: "Thank you for your email of 7 September 2016, which has been forwarded to me. You have requested a breadth of material from Engineers Australia spanning
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Sympathetic state librarians had advised me that due to the private nature of the professional association, their records were not archived anywhere for general scholarly access. Yet the "letters to the editor" embedded in their member-focused public mass communications may have seen fit to comment on important historical milestones in their collective life, such as the revision of their ethical codes.[7] Indeed, not only letters to the editor, but an entire series of primary-source books were available, written by a former president of the association, Brian Lloyd[8]. His approach to this topic over multiple works culminated in a diatribe regarding how the association had "debased" itself and its constituents by including "sub-professional" people as members. An excerpt of the synopsis of that book reads as follows:

> From the beginning of the 21st century, the leaders of [Association] became interested in the debasement of the "Profession' by including para-professional

from 1919 to the present. As you can imagine, this represents a voluminous amount of archived material, in paper and electronic format which would require an inordinate amount of time and effort to identify and locate. As a not-for-profit organisation, we do not have the time or resources to conduct such an extensive search of our records nor is it our policy to allow anyone to access those records given the commercial-in-confidence or confidential nature of some of the information within our archives. Unfortunately, we are unable to assist you on this occasion and wish you well with your research on the changing status of the engineering profession in Australia, especially with respect to energy conversion engineering and the rising global awareness of climate change with energy conversion processes. Should you have any specific questions about our current codes of ethics, framed by reference to how this relates to your topic of research, we will endeavour to assist." After having established relationships with two leaders currently affiliated with the association in the capacity of state or national managers of specific functions of the association whom I could copy to the message, I asked again for a newly-shortened list of archival sources in October 2017, but was told, "Thank you for contacting Engineers Australia again. Please refer to our Legal Counsel's advice and EA's National Manager response emailed to you on the 20 September 2016." My two contacts copied to the email chain either could not or did not intervene in order to try to change this institutional outcome. The association is indeed a nonprofit; its total revenue and other income for financial year 2016 was 41,566,000 Australian dollars (Engineers Australia 2017:4).

[7] Indeed, I was in fact able to source many, though not all, of the ethics codes from these old journals and magazines by referring to the "Institution Business" section of each month's periodical in order to determine whether a code revision had occurred or was imminent, and then hopefully checking whether prior librarians had seen fit to bind the Code of Ethics pamphlets along with the journal volume into the hard covers where they were stored.

[8] Chapter 4 describes an additional reason I had to read this author: personal recommendation.

> Engineering Associates within the 'profession' and describing them as 'engineers'. Such a proposition is so ludicrous as to be unbelievable for anyone familiar with the profession of engineering anywhere in the world [. . . .] The scene is now set for non-Professional Engineer members of [Association] to hold themselves out as 'engineers', thus perpetuating fraudulent occupational misrepresentation by individuals and their employers. Thus the ideal of a 'profession', and any expectation of truthful and ethical behavior, become meaningless. (Lloyd 2011:ii)

The last sentence in particular strongly links experiences of class-based boundary-setting to experiences of "ethical behavior" as something one can expect. It is very apparent that Lloyd and perhaps other actors within his expert community have held strong opinions about the boundary surrounding "Professional Engineer," the full imbrications of which will be addressed below. Recognizing the extensive and deeply-felt archival conversation regarding titles and their (mis)use—a conversation I almost accidentally encountered by looking for public historical sources regarding the association while I was searching to collect its prior ethics codes—I argue that the narrowed conceptual range of "engineer" and "engineering" has required cultural work. This work appears to have been carried out by the engineering association itself, thus contradicting my assumptions underpinning my 2013 emails to the librarian, namely that its "library" would be a [mere] neutral repository of information from which historical trends in thinking about "responsibility" could be seen. The engineering association had instead been an active historical agent. And as Lachlan's experience shows, the work of bounding "engineering" is still underway 100 years after the association's founding; but in actuality, it dates to a much earlier time.

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An early, broad conceptual range of "engineer" appears in the work of two economic historians who collaboratively tell the history of the "Amalgamated Society of Engineers" (ASE) in Australia, a union that preceded the founding of the association whose ethics codes I
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investigate. Buckley (1970) describes the same historical entity between the years 1852 to 1920, and Sheridan (1975) describes it between 1920 to 1972.[9] The A.S.E. (Amalgamated Society of Engineers) was a labor union that held a "quasi-monopoly of skilled work" (Buckley 1970:99) in its heyday. Buckley and Sheridan's own scholarly voices as well as their synthesized qualitative records show that "engineering" in nineteenth- and early-twentieth-century Australia seemed to mean almost any skilled work a person did with metal,[10] certainly not requiring membership in an engineering society or possession of a university credential, especially before the post-WWII expansion of university access. Furthermore, "skilled work" seemed to actively encompass <u>repair</u> work on a diverse range of machines originally fabricated overseas from the sparsely-populated Australian colon(ies) rather than solely the design or construction of new machines. The A.S.E was a branch of a British trade union. The parent union had experienced a lockout in 1852, and the Australian branch was actually formed on a boat approaching Sydney (Buckley 1970:1) exemplifying the colonial imbrications of this form of expertise. Two of the men on that boat subsequently moved to other states and founded other branches of the A.S.E. However, this institutional entity should be understood as completely separate from the engineering association founded in 1919 whose ethics codes I have collected both in the conceptual principle or basis upon which they brought people together, as well as their mission (i.e., the A.S.E. was active in

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[9] For clarification purposes, the A.S.E. changed its name to the A.E.U., "Amalgamated Engineering Union," circa 1920 (and what remained of the A.E.U. in 1972 seemingly merged back into another later organization called A.S.E. once again). This means that the timeframe of Sheridan's study largely relates to the A.E.U., and Buckley's timeframe largely relates to the A.S.E., but these two are effectively the same institution.

[10] Since the set of people and documents these two scholars discuss were metalworkers, their texts and records are an adequate laboratory in which to investigate the conceptual division, or lack of a conceptual division, between technicians and engineers. The case of civil, aerospace, and electrical domains of practice is not so clear from reading Buckley and Sheridan; yet, the density and specificity of their material provides a clear instance of how what once was unified became divided.

the politics of labor, whereas the professional association's staff and volunteers always disavowed that their institution had any union-related purpose).

As chroniclers of A.S.E., Buckley and Sheridan wrote in the 1970s. They helped scholars peer into a past even older than their own work, and in doing so, almost accidentally revealed the categories by which the A.S.E. unionists bounded their community and defined the basis of their solidarity. Buckley continuously references "the engineering industry." The union's purpose was to support "the economic interests of fitters, turners, smiths, patternmakers and other categories of craftsmen in the engineering trade" (1970:2). A.S.E. considered engineering itself to be an industry (Buckley 1970:297) in that there were many types of skills, but one "trade." Similarly, Sheridan references "the metal workforce," and in his subject index writes "engineering, *see* metal trades" (322). To consider this a clear group with the ability to restrict entry conceptually unifies a great number of metalworkers whom today would be considered tradespersons, excluded from engineering's semantic field.

But in practice, even in the late nineteenth century, skilled metalwork was both an industry in itself—"the engineering industry" as Buckley calls it—as well as a component of other industries. Vehicle and ship repair (Buckley 1970:14) as well as metal refining, casting, smelting, machining, and assembly are arguably skilled metalworks, and this work could have been done in mines and mills and publishing houses as well as foundries (Sheridan 1975:1). As time passed, the concept of engineering as <u>all of skilled metalwork and nothing else</u> has faded. New conceptual resources had to be found to create specificity for the term "engineer," and they would be found, simultaneously as the A.S.E. met its end in 1972, "predominantly a craft union right up to the end" (Sheridan 1975:18).

The death of A.S.E. and the social redefinition of “engineer” may be related. Specifically, the A.S.E’s control over skilled technical work appears to have been diluted by the non-admission of machinery operators and technicians. By retaining a vision of themselves as craft unionist engineers, where “engineer” meant skilled metalworker as opposed to common laborer, the A.S.E. appeared not able to withstand the introduction of automatic or semi-automatic labor-saving machines into the Australian economy, nor the introduction of their associated technicians and operators into the political economy of metalworking labor. A changing composition of the metal workforce was underway that made “metal trades” an increasingly ambiguous category: bicycles, cars, and electrical machinery were arriving in metal manufacturing facilities (Sheridan 1975:3) and people knowledgeable with the operation of these tools troubled the question of what it was to be skillful in metals. Machine technicians could not join the A.S.E., but they were able to unionize elsewhere.[11]

A.S.E.’s theory of its members’ political-economic situatedness as “the engineering industry” seems to have set them at odds with other unionists who wanted to create industrial unions that would cross class lines, such as the rail industry unions formed in the 1880s, which aimed to unite workers considered semi-skilled or unskilled along with workers considered skilled, thus drawing the boundaries of solidarity differently (Sheridan 1970:105, 297). Railways conceptualized as an industry was a paradigm that did not mesh with that of “engineering as an industry” (297). The decisions about whether machine operators, metal-oriented factory workers, and machine repair technicians counted as “skilled” was consequential for industrial solidarity: if

[11] After 1890, Buckley says that (1) “rival trade unions catering for the same trades,” and (2) “the fact that A.S.E. was a restrictive body which would not accept as members all those who were, or considered themselves to be, skilled engineers” created complications in trying to estimate what percentage of workers in “engineering workshops” (his term) were eligible for A.S.E. membership as the nineteenth century drew to a close.

A.S.E could not admit workers that it considered “unskilled” to its ranks, then A.S.E. would no longer be able to demand a “closed shop” or an entirely unionized workplace for their own members because these operators and repair persons were arriving to workplaces regardless of whether A.S.E. had unionized them (108).

The formation of engineering ethics codes, I argue, is one component of this ongoing Australian experience of dividing “engineer” from “skilled tradesperson,” and a tributary to it. According to Layton’s analysis of American engineering history, early twentieth-century speeches and publications elaborated an “ideology of engineering” (Layton 1986) defining it as a field of work empowered by engineers’ superior knowledge of technology, giving them the authority to lead and manage technology’s responsible social use. I call ethics codification a component or tributary to the experience of bounding “engineer” because it coexists in the types of speeches and publications that are Australian analogues to the places where Layton observed the American ideology of engineer as technology’s responsible master. I argue that the Australian codes are emerging in part from a disagreement over permissible educational background; they convey that social class markers of polite behavior are essential as a new means of solidarity unifying “the profession” that was beginning to emerge.

Globally, “engineering societies” originated from the 1820s to the 1880s.[12] The general meaning of an “engineering society” seems to be a collective body providing social events,

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[12] The “Institution of Civil Engineers” (1811), founded in London; the “Franklin Institute” (1824), founded in Philadelphia; the “Société des ingénieurs civils de France” (1848), founded in France; the “American Society of Civil Engineers” (1852) founded in New York; “Verein Deutscher Ingenieure” (1856), founded in Germany; the “Engineering Society of Japan” founded in 1879. Also, “Civil” engineering at that time had a good chance of being defined in opposition to “military” (Yates and Murphy 2019). Other organizations include the “Canadian Society of Civil Engineers” (1887) founded (http://eic-ici.ca/history/); the “Society of Telegraph Engineers” (1871), founded in Britain

opportunities for professional development, a forum for the development and internal distribution of specialized knowledge, and a forum for the pursuit of greater or more differentiated social status for members. Even before the lived experience of member engineers is taken into account, a multiplicity of loyalties appears to be built into the society of this genre: targets of its care and concern may be (1) members as enterprising professionalizing selves; (2) employers of members and their clients; and (3) publics and projects whereupon the professional skills in question are practiced. How are these mediated?

Code Contents

The first engineering ethics code in Australia appears in 1919 with the founding of the professional society, which strongly suggests that the most central event calling for the creation of the code was a felt need to draw attention and give the fledgling society a sense of importance. Worldly events of that year included the resolution of the Great War, with Australia's new membership in the League of Nations as a result, and it was a time of rising nationalism in Australia related to the loss of white settlers' lives in overseas battles on behalf of the Commonwealth's military interests. In addition to the threat of conscription, the war had also brought labor unrest, including the "1917 Australian General Strike" that started over the use of time-and-motion-studies within the New South Wales railway system and spread through other industries (Bongiorno 2014). The question of collective identity for technological workers and the question of what form and scale this solidarity may have taken appears to have been in the air. The year 1919 brought the formation of the Electrical Trades Union in Australia, which a

(https://en.wikipedia.org/wiki/Institution_of_Electrical_Engineers); the "Institution of Engineers of Ireland" (1835), (https://en.wikipedia.org/wiki/Institution_of_Engineers_of_Ireland). Former colonies of European powers in some cases established engineering societies later, e.g., "The Institution of Engineers (India)" was founded in 1920.

century later during my fieldwork was considered one of the most powerful, successful, and wealthy unions in the country. Overseas in the medical profession, a landmark for American professionalism in medicine in the form of the Flexner Report in 1910 led to medical education reform and its retrenchment within universities, together with the demise of non-university-based medical education and a decrease in the number and homogenization of the curriculum of U.S. medical schools (NPR 2010).

Today, the professional association has very little to say on its website about the reasons for its origin other than that it "was founded to accommodate the needs of both engineers and a modernising Australia." A commemorative book by a former association president on the occasion of its fifty-year anniversary records a possible reason for federating state associations into a national one: "The new Australian institution must be able to command the respect of engineers, public bodies, and the general public, both at home and abroad, to speak with authority on questions of engineering, to raise, maintain, and if necessary, defend the professional status of engineers, both collectively and individually" (Corbett 1973:16). Respect and authority for the institution itself were perhaps better attained if its purview was defined as national rather than regional. Furthermore, "nearly all professions have some kind of formal ethical code" (Abbott 1983:857), such that having a code and being a profession are to some extent mutually definitional.

The first president, William Warren,[13] proposed the code along with "the registration of Engineers with the Institution as their qualifying body, coupled with restrictions on the use of the word 'engineer'" (Corbett 1973:53). Restriction of the term's use evokes the possibility of an

[13] He was a "public works engineer" who had worked in the New South Wales Department of Public Works. At Corbett's time of writing he was described as a "Civil Engineer," but he seems to have preceded the category of civil engineer in time.

industrial control strategy: by restricting entry into the field of work, more negotiating power could be gained by the artificially narrowed collection of would-be workers. The status of the profession as a whole was to be defended by intra-group loyalty: the majority of all early codes affirm this by their balance of topics, as described below.

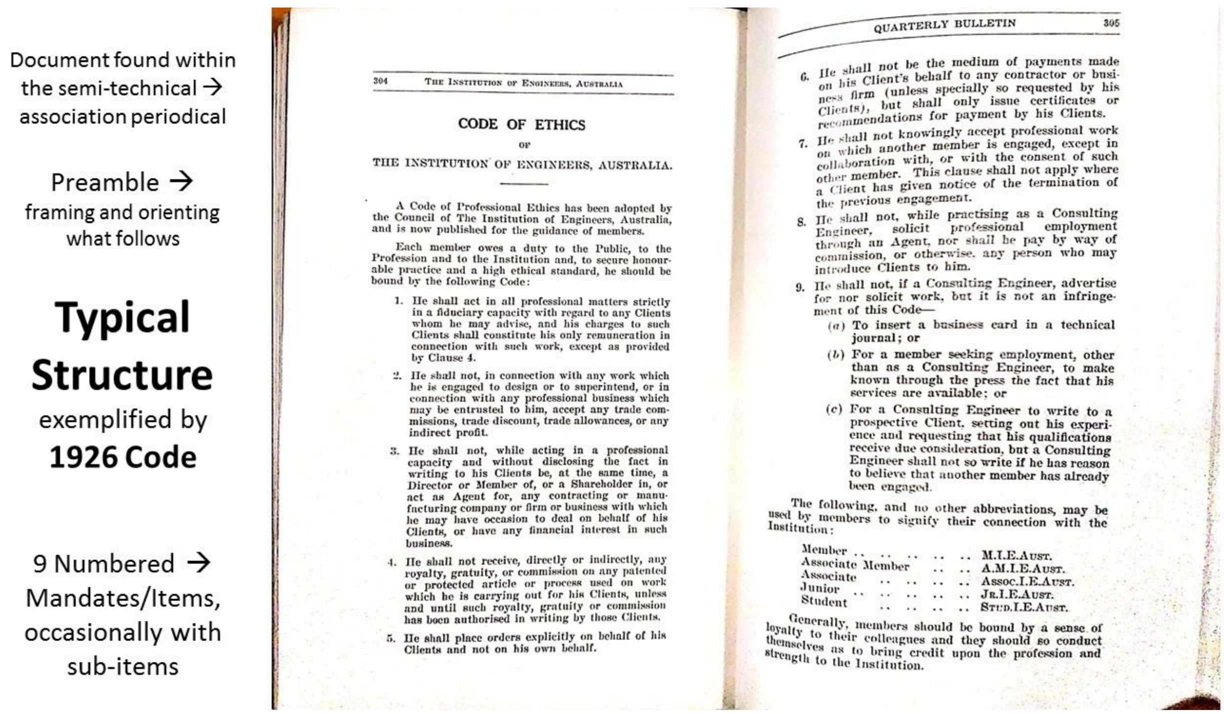
The Warren Code appeared in the first president's introductory address to the society in 1919 as a short list of precepts reprinted in the society periodical as part of a record of his inaugural speech. Six items of prohibited behavior are listed, which indeed set the thematic contours for future codes. Paraphrased and simplified, they are: not taking bribes, not harming another engineer's reputation, not seeking "to supplant another engineer after definite steps have been taken towards his employment," not underbidding peers, not providing secret peer-reviews,[14] and not self-advertising "in laudatory language." Loyalty among engineers is paramount, since five out of the six prohibitions are formed to defend the well-being of a peer engineer or "the dignity of the profession," and only the first one, regarding bribes, is in defense of the well-being of projects and clients.

The next code available as a primary source is from 1926 and expands the six prohibitions into nine, changing the numerical balance of items regarding engineer-client versus engineer-engineer relationships, but not substantially changing the topics discussed. The first six are an expansion of the 1919 code's description of how to manage client' and contractors' money, tips, and debts, culminating in the strange but gentlemanly requisite that an engineer not be a literal paymaster:

[14] The exact wording of what is forbidden is "To review the work of another engineer for the same client, except with the knowledge and consent of such engineer, or unless the connection of such engineer with the work has been terminated."

He shall not be the medium of payments made on his Client's behalf to any contractor or business firm (unless specially so requested by his Clients), but shall only issue certificates or recommendations for payment by his Clients.

The final three prohibitions are still about *not* providing external expert opinions (specifically, not beginning to work on a project on which another engineer is already working except with his consent), not soliciting work through an agent, and not advertising, except in a few listed and highly-specific ways, such as by inserting one's business card into a technical journal. Overall, 1926 is not a substantial revision from 1919.



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CODE OF ETHICS

OF

THE INSTITUTION OF ENGINEERS, AUSTRALIA.

A Code of Professional Ethics has been adopted by the Council of The Institution of Engineers, Australia, and is now published for the guidance of members.

Each member owes a duty to the Public, to the Profession and to the Institution and, to secure honourable practice and a high ethical standard, he should be bound by the following Code:

1. He shall act in all professional matters strictly in a fiduciary capacity with regard to any Clients whom he may advise, and his charges to such Clients shall constitute his only remuneration in connection with such work, except as provided by Clause 4.
2. He shall not, in connection with any work which he is engaged to design or to superintend, or in connection with any professional business which may be entrusted to him, accept any trade commissions, trade discount, trade allowances, or any indirect profit.
3. He shall not, while acting in a professional capacity and without disclosing the fact in writing to his Clients be, at the same time, a Director or Member of, or a Shareholder in, or act as Agent for, any contracting or manufacturing company or firm or business with which he may have occasion to deal on behalf of his Clients, or have any financial interest in such business.
4. He shall not receive, directly or indirectly, any royalty, gratuity, or commission on any patented or protected article or process used on work which he is carrying out for his Clients, unless and until such royalty, gratuity or commission has been authorised in writing by those Clients.
5. He shall place orders explicitly on behalf of his Clients and not on his own behalf.

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6. He shall not be the medium of payments made on his Client's behalf to any contractor or business firm (unless specially so requested by his Clients), but shall only issue certificates or recommendations for payment by his Clients.
7. He shall not knowingly accept professional work on which another member is engaged, except in collaboration with, or with the consent of such other member. This clause shall not apply where a Client has given notice of the termination of the previous engagement.
8. He shall not, while practising as a Consulting Engineer, solicit professional employment through an Agent, nor shall he pay by way of commission, or otherwise, any person who may introduce Clients to him.
9. He shall not, if a Consulting Engineer, advertise for nor solicit work, but it is not an infringement of this Code—
   (*a*) To insert a business card in a technical journal; or
   (*b*) For a member seeking employment, other than as a Consulting Engineer, to make known through the press the fact that his services are available; or
   (*c*) For a Consulting Engineer to write to a prospective Client, setting out his experience and requesting that his qualifications receive due consideration, but a Consulting Engineer shall not so write if he has reason to believe that another member has already been engaged.

The following, and no other abbreviations, may be used by members to signify their connection with the Institution:

Member	M.I.E.Aust.
Associate Member	A.M.I.E.Aust.
Associate	Assoc.I.E.Aust.
Junior	Jr.I.E.Aust.
Student	Stud.I.E.Aust.

Generally, members should be bound by a sense of loyalty to their colleagues and they should so conduct themselves as to bring credit upon the profession and strength to the Institution.

Figure 3.1 Exemplary Ethics Code Structure (1926)

From 1926 until 1950, no codes were saved in the available archived periodicals, meaning either that they were not explicitly revised or that they were not bound into the journals that academic libraries saw fit to save. The former president Arthur Corbett's records of general society history fill in some of that under-described interval, explaining that by 1934, discussion of the circumstances of "consulting engineers" and whether the code adequately accounted for them had arisen as a matter of concern. In 1938, not using a salaried position to compete unfairly with other engineers who were unsalaried became an ethical mandate, but it was described in a separate document focused only on the topic of consulting engineers (Corbett 1973:169), and separate working groups seem to have split off from the general ethics code revision process to consider the case of consulting engineers.

Also in this timeframe, the middle of the century is the moment when "responsibility to the community" is recorded as a concern. In 1948, an engineer's responsibility to the community was said to come before his responsibility to other engineers (Corbett 1973:169), and this topic was considered for inclusion in the 1958 code, but not adopted (170).

The 1950's code—available as a one-page document foldable into a four-faced pamphlet—marks a moment when the "consulting engineers' subcommittee of council" has its function rolled back into those of the code of ethics committee generally (Corbett 1973:162). Sub-items in the 1950's code include Conduct of Members, Technical Evidence, Design Competitions, and Consulting Engineers, with up to nine subitems listed under each. All of the prior concerns in the 1919/1926 codes about the dignity of the profession, proper financial management, and the reputations of peer engineers are collapsed into three terse topics in the Conduct of Members section. The question of "giv[ing] advice on technical matters," especially when other engineers are already at work on these, expands from one topic to five and a few subtopics, explicating how "salaried" or "consulting engineer" status affects the proper course of action for providing technological advice on projects where other engineers have worked, or are currently at work, with or without their knowledge or consent. Arguably, the rest of the code, about competing for work and acting as "an unbiased and independent engineering authority" while positioned as a "consulting engineer," is about how to manage the fact that an engineer may be part of one (or multiple!) entire businesses that are operating in collaboration and competition with other businesses. Excessive advertising and using agents to find work remain prohibited.

Between 1965 and 1972 is another window of time when code revisions may have been made, but their records were not bound into the institution periodicals saved by scholarly libraries, and Corbett's history is the only way to know that the 1959 code permits advertisements by consulting engineers under stated conditions (168), and the 1964 code amends seven clauses and adds supplements to four others (171).

The only year that the code fits entirely on one page in in 1966. It has only two sections, the Preamble and the Code, and nineteen items that are each stand-alone rules not grouped into any thematic subsections. "Duty to Community" appears for the first time and is instantly promoted to the first item on the list. The Preamble refers to new needs beyond financial responsibility and preservation of dignity: "the further development of civilisation, the conservation and application of natural resources, and the improvement of the standards of living of mankind" are at stake, and indeed, "depend largely upon the work of the Engineer," who as a group must also "strive constantly to widen their knowledge and improve their skill." Within the eighteen other concerns, all of the prior ones re-emerge but are written more briefly to make room for new mandates: to give credit to subordinates and help them advance; not to disclose confidential information or use it for personal purposes; and not to "continue in partnership with, nor [. . .] act in association or conjunction with, any Engineer who has been removed from membership of the Institution because of unprofessional conduct." Overall, in 1966 we see the efficacies attributed to the engineer widening, from the grandest scales of society and nature to the most intimate scales of properly leading subordinates, applying "diligence" at work, and writing contracts "with scrupulous impartiality." We also see an emerging darker undertone that some ethical conflicts have no easy answer to: in the second numbered item, speaking factual truths may help the community but also be against the interests of other engineers, and in the final item, the association has final arbitration over who is an ethical person, since to continue working with a person who has been ejected from the association is now deemed unethical. The relation of the individual to the collective is at stake as an ethical tension. In the same historical document that begins to figure engineers as more broadly efficacious characters, the professional association rather than the engineering self gains more authority as the ultimate locus of determining what is ethical[15], to the extent that members must align their own decisions about whom to collaborate with into correspondence with its own boundary-keeping.

The 1972 and 1979 codes were given to me by a colleague of David Hood, a former national president of the association, and they were quite similar to one another. The contents remain brief, contained in a single, folded page printed on all four panels—easy to remember, as my contact pointed out. The structure of both years is a preamble followed by an itemized code and then a following section on "Interpretations." While the 1972 code seems to be a reformatted reprint of the 1966 code, the 1979 code condenses the profusion of different items regarding preserving peers' reputations and removes the items about care and credit for subordinates. The latter is folded into a general mandate that everyone needs to continuously pursue professional development. To "perform work only in their areas of competence" is the newest emerging mandate, and the profusion of information about consulting engineer behavior is cut back in volume, perhaps because the situation of being a consulting engineer had become so widespread that it was no longer a special case. In 1979, the explicit reference to dignity and propriety that

[15] For more discussion of what is at stake in this shift, please see Chapter 4.

had usually marked any Preamble gets demoted down into the document body text and is replaced by a new implicit threat: “Members acting in accordance with this Code will have the support of the Institution.” This repositions the location of dignity and status into the collectivized association itself as a probable but revocable guarantor of “support” to members, rather than locating dignity in an abstract “profession” or in concrete individuals.

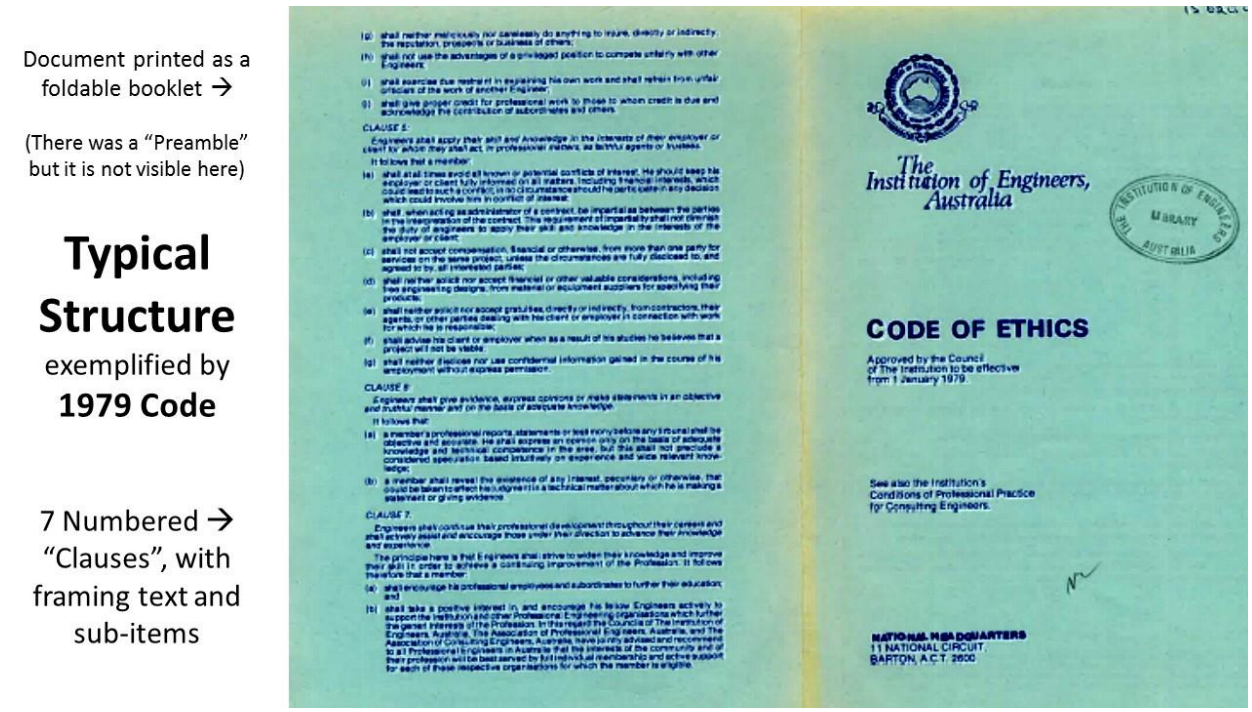

Figure 3.2 Exemplary Ethics Code Structure (1979)

By the time the ethics code for the year 2000 was written, authors could still make reference to something called “engineering matters,” but “the engineering industry” taken-for-granted in the 1890s (Buckley 1970; Sheridan 1975) had vanished from memory. The 2000 code has ballooned from the single page of its four predecessors to 4,786 words and eighteen subsections total, the first two of which are recognizable as a “preamble” and a “code of ethics,” and the rest are wide-ranging and titled in ways that do not necessarily reflect the contents of that subsection.[16] For example, after the code with its nine items, there are three "Cardinal Principles" and eleven "Tenets" together in a subsection solely called "Principles" and flanked on either side by a subsection called "General Guidance for Members" and another subsection called "Interpretation." Notable added concepts include reference to engineering standards (see Chapter 1) for the first time, and also a subsection about "areas of competence and description of qualifications." Avoiding misrepresentation of one's *qualifications*, a new twist on practicing within one's area of competence (1972, 1979) briefly appears within the 2000 code itself in a strikingly provocative way. Namely, disagreeing with the Institution regarding the definition of an engineer is now considered unethical: engineers "should acknowledge that the terms 'professional engineer' or 'member of the engineering profession' are used to describe only those persons eligible to be Graduate or Corporate Members of the Institution." (6). The "bottom up" of ethics have been repositioned to "top down."[17] Although no records were apparent to me about how to make amendments to the ethics code if one is a rank-and-file association member, there is now detailed, explicit information about the procedures and steps to follow when testifying as an expert witness, when "whistleblowing" to inform the public about dangerous behavior at one's own organization, when giving critiques regarding other engineers' projects, and when making public comments or statements. Regarding the last:

> The presentation of arguments should be made in a way that maintains and enhances community trust in the values and expertise of the membership of the Institution. A loss of community trust would be contrary to the best interests of the community in circumstances where the member's comments might be crucial to the welfare, health and safety of the community.

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[16] In another internal contradiction, a "General Guidance" section states: "This information and any express or inferred provision or statement does not in any way form part of the Code of Ethics." But four sentences later, it is explained that the subsequent text will be "Cardinal Principles, which guide all behavior governed by the Code" (4). Does this mean that the cardinal principles are both <u>not part of</u> the code and are also a "guide" for "all behavior governed" by it?

[17] This insight is owed to Eric Triantafillou.

The ultimate reason for why public trust in the profession must be maintained is described as the community's own "welfare, health and safety." Community health and safety has been listed as a priority of engineering practice beginning in 1966; but in the 2000 document, community trust in engineers is positioned as a means to the end of preserving concerning community health and safety. Status, dignity, and reputation—for the first fifty years ends in themselves—are now suggested as instrumental means towards the well-being of non-engineers. Maintaining the boundary around the title of "engineer" is partially the work of the ethics code because engineers are taken as worthy of esteem because unlike tradespeople, they are bound by it and thereby positioned as greater value to "the community," therefore implicitly deserving of better treatment by "it."

The 2010 code, the last that could be found, is dramatically shortened in length once again to 914 words, a brevity not observed since 1926. Four two-word items (Demonstrate Integrity, Practice Competently, Exercise Leadership, Promote Sustainability) each have three sub-items. What this code seems to gain in memorability, it may lose in specificity: e.g., under "1.1 Act on the basis of a well-informed conscience," item "1.1.c Practice Competently" could be interpreted as a conceptual extension of 1.1, thereby something like "Act appropriately, and in a professional manner, when you perceive something to be wrong" (3), but that would have been a personal interpretation to fill in the gaps between a reference to conscience and a reference to competence. There are no preambles or subsequent supplementary information. Because no expanding detail is more than a sentence in length, the 2010 document effectively gives less information to outside observers about what particular challenges are expected to emerge and what would be improper responses to that which could constitute the "fraudulent, corrupt, or criminal conduct" that should be avoided.

Below, the presence of the most common six recommended or forbidden actions are graphed in their appearance over time.

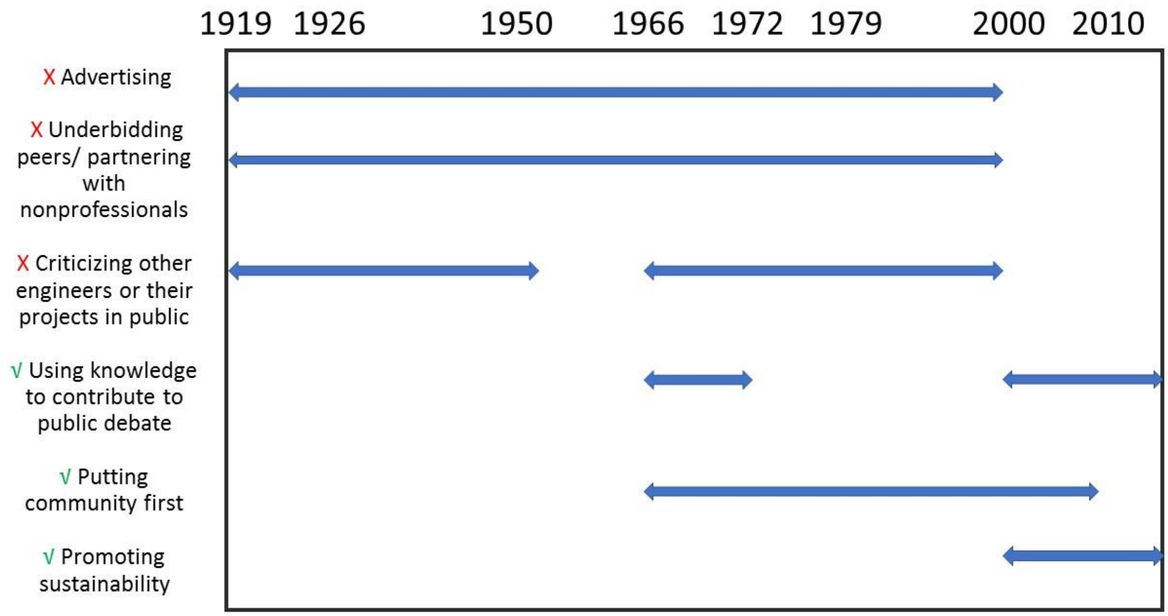

Figure 3.3 What Engineers Are Responsible For - Graph of Ethics Code Thematic Content

In summary, only in the 1959 code were paragraphs written about the engineer's responsibility to the community, which then stay as a concern until the code of 2010. Only in 1972 does the environment appear (although "natural resources" are referenced in 1966). However, from the first code onwards, even to 1979, there is elaborate discussion around how consulting engineers should not "compete unfairly" with each other and how advertisements should either not be posted or should be posted in clearly regimented ways so as not to harm the profession's reputation or drive down the price of labor. Early codes forbid forming limited liability companies generally as well as other ways of creating business partnerships with people who are not formally educated as engineers, as this seems to have been considered unfair competition. The codes even to the present still address not speaking outside of one's "areas of competence" in public; this seems to be the recent transformation of an older sentiment that one should not publicly criticize the designs of a peer practitioner.

As Calhoun writes about the professionalization of engineers in England, "the new professional man brought one scale of values—the gentleman's—to bear upon the other—the tradesman's—and produced a specialized variety of business morality which came to be known as 'professional ethics' or 'etiquette.'" (1966:158–59). Indeed, these code contents attend to what could be called, in a phrase, business etiquette.[18] I consider ethics codification a tributary in the sense of a small waterway (representing social process) flowing into a larger stream (representing a larger social process with more causes) since it intensifies social distinction: the elevation of professionals with the "right" knowledge and values is necessarily coterminous with the exclusion of would-be professionals who have the wrong ones. As phrased by sociologist Magali Larson (1977) in her history of professionalism's emergence, professional ethics codification aids in a group process of status seeking called a "collective mobility project" for the set of people seeking to distinguish themselves as those governed by the "higher standards" of the code. Observation of the trajectory of what is written into code documents over time supports the interpretation that a "collective mobility project" is underway within engineering

[18] Davis (1990:172) discovered an arguably similar trajectory in an American law school: in the 1940s and 1950s, a course considered to be on "ethics" had been taught, but was ended in the 1960s, and remembered as having a curriculum "about things like how large a sign you could hang over your office and whether you could give someone your business card" as well as the history of law as a type of practice. Davis opines that "the course seemed increasingly irrelevant in part, I think, because the old Canons of Ethics had been written for a different age, the age of solo practitioners and individual clients. The students saw legal work increasingly concentrated in government agencies and large firms with corporate clients."

societies. Specific codes exemplify the nature of behavioral expectations that were being used for symbolic boundary-keeping in these fields of twentieth-century knowledgeable work.

As the apparent need for these boundary-keeping codes suggests, permissible educational background emerges as a new, third means of inclusion or exclusion that is different from either the craft union approach of the A.S.E. (horizontal integration, it could be called, across all metal trades) or the industrial union approach of the railroads and potentially other industries (vertical integration, across all workers in an industry). From 1919 onwards, abiding by the ethics code appears to be a means of participation in "engineering" whose boundaries are gradually coming into focus as drawn institutionally around possession of educational credentials. In the nineteenth-century metal trades, apprenticeships had been thought to be the way to begin a career (Buckley 1970), and they retained major importance into the 1950s (Sheridan 1975:270). Corbett, the historian of the first fifty years of the engineering association, writes that at the moment of first accrediting Australian engineering schools—namely 1963 through 1971—"there was at that time a survival of the practice of training engineers by pupillage in a number of Government Departments."[19] Trained-on-the-job was falling out of favor as a mode of professionalization, yet, as I know from discussing resumés with some of the most senior practitioners I was able to meet, the speed by which trained-on-the-job lost favor was limited by the fact that positions of association leadership had already been attained by individuals who had been trained in this way. Also, in Corbett's words, "the purges which preceded World War II

[19] Over the first half of the association's hundred-year life, state corporations were an important place for the training of new recruits into engineering as expansively understood. The State Electricity Commission of Victoria was remembered by my interlocutors quite fondly as a place with an elaborate research department as well as an inclusive workplace; these memories are seen through nostalgia-colored lenses since the government electric company was privatized in the 1990s and its workforce numbers slashed.

brought engineers with European qualifications to Australia" (102–103), raising the need to commensurate foreign-gained credentials with local ones.

By 1956 or 1957, the engineering association had solidified its requisites for membership in such a way that graduate training schemes within workplaces, including the "cadetships" in government departments, had all been accounted for as part of the specified combinations of education and experience that would meet policy requirements for membership—policy requirements that, in their latest and most revised form, are still described in great detail on the association website and through webinars and meetings that I attended in multiple Australian cities between 2013 and 2017. In these acts of enclosure, practical experience in the same workplace as skilled engineers did not count as engineering experience unless a suitable academic qualification had been gained before that work experience took place.

Aspirations

Having argued that the codes are emerging in part from a long-running historical disagreement that took place over permissible educational background, I would like to introduce my interlocutor, one of only three people I met during my 2013–19 fieldwork, who explicitly argued that the ethics codes of the engineering association held social relevance and actual or potential social efficacy. David Hood, a former national president of the association, had taken a large role in creating a reform that placed responsibility to the natural environment as a component of the code in 2010. He is perhaps also the only person I met who declared that I should please use his actual name in my writing process. He also brought me into contact with two anonymous contacts who supported me in obtaining archival copies of the old codes from their personal filing cabinets.

It brought me enjoyment to speak to David because in contrast to many adults who shared their time with me on behalf of this project, he seemed less shy, less concerned that his morality was private so that its potential contradictions with his visible mode of living could not be observed. Instead, his obsession with critiquing Australian failures at preserving future environments was a feature of the personality he shared freely with the world. David, in his public life, had been able to work with multiple environmental NGOS, at one point receiving appointment to a leadership role while I watched from the seats at a public, end-of-year event. Perhaps due to hierarchies of age, race, and gender, he was comfortable with a public image as an edgy sustainability champion who would hold fellow senior men accountable regarding the correspondence between their actions and their words. This contrasted with my other interviewees who fell into less privileged demographic categories, including the unemployed, who seemed to speak as if they did not feel free to give out any information about either themselves or any project they may have been involved with, and who seemed ill at ease when my questions created opportunities to transcend the boundaries between a private self (free to experience judgmental emotions regarding his or her work), and a public, professional face (unceasingly polite, discreet, optimistic, and usually unable to say anything much.) David Hood and one of two contacts he introduced me to distinguish themselves from many of my other contacts in that they did not seem subject to the same constraints. I remember drinking a lot of red wine with him and his cast of co-conspirators of diverse ages and genders near a university office where he held an adjunct professor appointment, or on the sidewalk terrace of a pesticide-free flower shop run by women florists.

David was a public figure who during his time as president of a national professional association led the revision of the 2000 ethics code into the 2010 code. When we first met in

Brisbane, David Hood was working to “embed a culture of sustainability” (email, July 31, 2013) within engineering education. Getting a “framing culture of sustainability” into the profession means “taking the boundary off of your problem” to include “upstream and downstream” from where the problem-to-be-solved would have otherwise been defined. For example, “Where did that material you just specified come from?” The sources and destinations of the components of engineered projects would be included in his community’s thinking if they were able to live within this “framing culture.”

He had recently met with some collaborators and had drawn a diagram that conceptually mapped how this could be achieved. In discussion with me, he emailed me the image they had come up with:

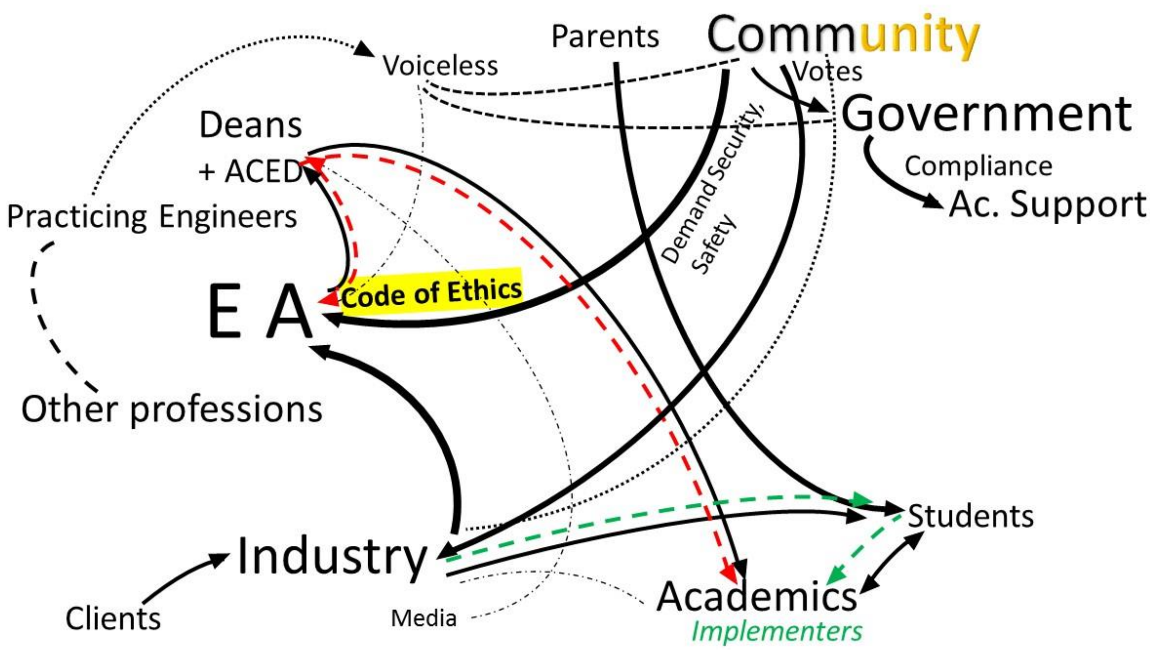

Figure 3.4 David Hood’s Diagram, photographed 2013
Rendered into Powerpoint Image by Author *(Orange and Yellow added)*

Sweeping from the top right to the middle left of the diagram was a causal arrow for how the community, “Comm.,” would affect the engineering association, written as “EA,” by means of the code of ethics. In other words, the code of ethics would be an institutionalized interface to all the under-defined features of social life not conceptualized as “industry.” Having received the results of these two arrows of influence—industrial and community—the association EA would then be able to directly affect the deans of engineering schools. These would affect academic professors of engineering, who would thereby in a bidirectional relationship “embed a culture of sustainability” among students and themselves. At the time of writing this diagram, David aspired for the community to speak to the engineering association through the ethics code. In contrast to the prior codes, the diagram acknowledges complexity.[20]

We can also see in this diagram that David and his collaborators seem to picture the association, “EA,” as having very little efficacy. The only solid arrow that emerges from “EA” runs toward the “Deans and ACED” (perhaps “Association of Civil Engineering Departments”), although a few dotted arrows do emerge from the association to impinge upon “the voiceless”—David’s way of referring to the natural world—and “practicing engineers.” The message of this diagram as I interpret it six years later and with the benefit of having personally interviewed substantial numbers of people affiliated with or affected by the engineering association is that David and the other anonymous authors were expressing their specific common sense that the association did not have a high level of agentive efficacy in its interactions with almost any other social “group” except the deans of engineering curricula.

Something not included on this diagram, but certainly included in his thinking regarding how engineers become “safe,” is attainment of status and certification by climbing up the grades

[20] Insight from Jack Mullee.

of membership within the professional association. As a member of the organization since 1968, David never sat for a competency exam because he attained the highest grade of membership before competency standards were introduced. When asked why he places a lot of emphasis on "chartered status," David defines the meaning he sees in the Chartered Professional Engineer certification, or CPEng, as follows: "You are deemed as safe for the community. The bridge won't fall down, the building will stay up, the chemical process won't kill anyone." Implicit in this thinking is that adequate knowledge held by practitioners is sufficient for the production of safe infrastructure in the world. He holds up the "Professional Engineers Act" of 1961 as "a big win for the profession," since "around the world, it followed on from there to start developing competencies for professional engineering." This act caused engineering salaries to be adjusted, and David's reference to it relates to how in his thinking, he maintains a strong division between trade and profession. Engineers develop standards and codes, he believes, tradespersons use them—like the code for what thickness of wire to use in any given circumstance. In this theory of how "chartered status" has social efficacy, "chartering" assures right knowledge, and right knowledge ensures right practice, since it is translated without interruption or modification from the chartered engineer to all of the tradespeople building the designed item. While his vision is conservative in where it locates agency over correct and responsible practice, it is still more expansive than some of the more commercial representations of how engineers can resolve climate change merely by creating new technologies. David believes engineers need to lead in the resolution of climate change, but not necessarily through innovation. Regarding new technology, he says that "we are not getting rid of the things causing the problem." His theory appears to be that just having "right knowledge" in and of itself will necessarily bend engineers towards climate solutions, just not in the form of innovations.

I find it hard to share his imagination that this specific efficacy of the certification process is likely to play out. I see the engineering codes as a historical institutionalized means of differentiating practitioners from the public; yet, he sees their tenets as a means of connection to the public. In a sense, he is implying that he speaks for the community in expressing what the terms of the "competency standards" are, something that nonmembers cannot hope to modify. He is positioning competency in sustainability and social and environmental responsibility itself, as abilities already subsumed within expert practice, the presence or absence of which can be tested and verified as if it were a form of knowledge instead of a form of willfulness or a form of eventfulness in an unruly world beyond the designer's knowledge and will.

Anthropologists of ethics have considered centering people's experiences of maintaining intersubjective relationships as the location of "the ethical" (Zigon and Throop 2010:8). However, when defined and enforced through a professional certification, being formally ethical as well as being formally educated seems to be a way to curtail large swathes of intersubjective relationships—such as with the public politics of energy and with tradespersons or uncertified practitioners—and instead cultivate others, such as potential employers and high-status colleagues. In this engineering association, agreeing nominally on the Code of Ethics, like agreeing formally on the need for an accredited degree, is a socially-recognized means of differentiating oneself from would-be peers. Never in my research did I encounter any "community member" making reference to the Code of Ethics of an engineering association; it seemed to be solely the concern of people who, like David, already had a personal stake in the meaningfulness of the distinctions created by the professional association because they had already received high distinctions from that association or had already donated their time and membership fees to the association, or both. Despite David's theorization that safe technologies result from knowledgeable practitioners, examination of the historical trajectory across the century of codes shows that their content has been completely unrelated to questions of appropriate, benevolent, or responsible technology. There is more evidence that they serve social division and distinction within an already small number of members and participants, rather than stand for the construction of common causes across “community” and “profession.”

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It is a Sunday night, Monday in Australia in 2019, and I am breaking my self-imposed rule not to conduct any further fieldwork during the year of actual dissertation writing. I am doing so by taking a call with another research participant, “Andrew,” both because I get genuine enjoyment from this professional friendship, but also because he might have new information for me of a very elusive sort concerning the hopes, aspirations, and procedures enlivening the very specific process of organizational change I have been tracking. By email, I have already told Andrew that I have excavated his association’s “Code of Ethics” from 1919, 1926, 1950, 1966, 1972, 1979, 2000, and 2010 from old publications and presented a conference paper about these. He responded that there may be yet another updated Code of Ethics in the works for next year, and that he was willing to tell me something about that. In arranging to speak, I reminded him that I want to use what he can possibly tell me in my dissertation, causing him to email back that we can discuss “what gets taken as research data” on the call itself.

Sitting down to speak, Andrew says he’s tired at the end of the year. I commiserate, but persist with the idea that this is an on-the-record conversation, expressing that I do not want to know information from him that I cannot use in my research, since my research is the ultimate purpose for everything I have done in his country. I’m prepared to tell him that I want to take
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"information about him, and information about historical events" away from the call for my work. But he objects; there's a thing he really wants to say *in camera*.

"I don't want to hear it," I say. "Please, keep things easy for me; I don't want to know things I'm not able to report even while anonymized."

He accepts and decides to share lesser secrets. The fact that there will be another Code of Ethics is not public yet, so he has to wait until the Code is disclosed publicly before formally reporting about the motives and logics for the change, as he had suggested—although I protest:

"You *know* they're never going to disclose anything about their reasoning. You *know*, that even when the change is public, they will never say why they made it."

"The process does involve the National Congress," he alludes (mentioning a committee of the engineering association that I am unfamiliar with).

In the most general terms, the motivation seems to be that there is a "Professional Conduct Committee" that uses the Code of Ethics to determine whether people need discipline, and it may have been hard to discipline people using the current Code.

"That may be!" I add. "2010's is far shorter than any of the ones recently before it. But I didn't know if the Codes were used in that way."

"It's always happening," he says.

Now, in his office on the other side of the world, I can tell he is calling up on his screen the 2015 version of the Royal Charter and By-Laws of the engineering association where he is a volunteer officeholder. Maybe a reason why he and I became friends is a shared taste for historical documents as a way to gain perspective on current institutions. I still think he is getting distracted from my purpose of the call, which was to gain from him the story of why the code is being revised, how the process of revision is unfolding, who is being included, what are their aspirations, and what are *his* aspirations for this process. But this is his way of approaching the question, and I let it unfold.

"I think in the Bylaws of Engineers Australia it says . . . Bylaws, section 12.2: members must at all times comply with . . . professional conduct . . . . The *Board, must prescribe,* a Code of Ethics," he emphasizes. "It may not be that the Code of Ethics [is meant to be what people are meant to be disciplined against]." Although my notes don't preserve his exact words, he is beginning to formulate a personal revelation.

"Have you been involved in any of these cases?" I ask, meaning disciplinary hearings. "No. Let me just go back to the bylaws . . . ." By thinking aloud, he tells me "I'm uncomfortable with the Code of Ethics being played around with too much." He concludes that his organization's Charter, Bylaws, Regulations *and* Code of Ethics are all supposed to shape the obligations of a member as a set, and he thinks other agents now seeking to revise the Code of Ethics, which "is reviewed every now and then," are misdirecting their work. But who are they?

"Those which are included in the review, and how, I don't know. No one has made that transparent. The National Congress could have sought out the change. Discipline regulations, this is one of their responsibilities. Responsibility of the National Congress, not the Board. It [presumably the bylaws on his screen] doesn't say how the Code of Ethics may be changed." *He's approaching this from a very abstract vantage point,* I think to myself.

"What are your aspirations for the process of revising the Code?" I eventually ask.

"Transparent, I guess. Transparency in how it's set." *Quite a literal answer. He's talking about qualities of the process of change rather than about the code's worldly efficacy, which I intended to ask about.*

“Do you have a lot of friends working for Engineers Australia who are working for transparency within the association?” I ask.

“They would be the minority,” Andrew’s voice is starting to sound audibly strained by the challenge of critiquing his colleagues, which is against his professional standards. “By ‘working’ in the association, do you mean the volunteers or the paid staff?” he asks. *Andrew is a volunteer and is probably aggrieved at some of the paid staff. Another digression. But it’s a shame how so many people are working for free just to gain resumé prestige over there*, I think.

“Cultural change” is needed at the association, he comments. Too much of a “business-as-usual-mindset” has set in.

“You think it wasn’t always this way?” I ask.

“There has to have been a point, when it was first established, when it was all volunteer . . . .”

Now, I finally get to request: What are his aspirations for the Ethics Code itself?

> Slowly and haltingly, Andrew stages his thoughts:
>
> “There’s . . . the Ethics Code . . . the discipline associated with the Code, and . . . the behavior of the profession associated with the Code. My aspiration would be to promote the right behavior in the professional people. You know, because . . . people could . . . work for an insurance company. And their company could expect them to do something, to line things up, so that the interests of the people buying insurance are not served. My aspiration is that the Code prevents that kind of behavior. . . . . Bettering the community, in how engineering is applied. . . . For example, engineering is kind of expanding into using social data. It used to be that you would need to have conversations with people, you would need to set a problem statement . . . You want to ensure that the code uses social data in ways—the code is inclusive, to ensure . . . the betterment of the planet. Rather than by being driven by business or industry—that industry and business draw the direction. You lose that objectivity and oversight. To build things: are they heading society in a good direction? [It’s about] how engineering practice helps rather than hurts.”

In the balance of our call, I have more to say and decide to free myself to share some thoughts. I invoke just one "component," as I call it, of the historical processes I have read about, by which the engineering association seems to have developed away from its original composition and spirit: namely, Lloyd (1988) talked about a mass-shift from public to private employment of engineers in the 1980s. The nature of everyday workplace norms in private companies since then may have affected how members think about "norms for transparency" and hence how they act in places like the association, right?

"That's a massive assumption," he retorts, immediately and completely skeptical. "How would you even go about testing that?"

I indulge myself in talking for a while about how not everything social researchers or historians take as true can be tested; sometimes these days people use "trained judgment" (Daston 2007).

Andrew finishes his thought process about the relative roles of the several governing documents, decides aloud that the Code of Ethics is "NOT the right thing to change," and confidently declares that he "plans to make a phone call." When I ask, he confirms that yes, the Code of Ethics is also used in the "CPEng process," the process by which aspiring professionals gain a post-nominal "CPEng" certification by undergoing essay- and interview-based examinations and paying a fee to the association. This practical purpose of the code, very alive to me from my investigations, had fallen out of his ready-to-hand awareness of how he hoped the code would function, although I assume he must have gone through it to gain his own postnominals. Andrew also really wants to get his secret off his chest, so I dutifully listen to it *in camera*.

Before we go our separate ways, I add, “You know, when I was looking up the name of that essay people have to write to obtain their credential—I cannot remember its acronym, something like Competency Report—you know what I found? The internet is just FULL of paid services that will ghostwrite those essays for a person. You know, young people—like my research participants! People who just want to work, and there is a procedure standing in their way, like the need to submit an essay? They’re just hiring ghostwriters, Andrew, some at least. From the number of websites that’ll write your essay for you, I think the business is booming!”

He doesn’t really have an answer for this specter of refusal-to-follow-the-rules that I am conjuring, like a cloud of smoke, around the edges of an otherwise shiny, crystal-edged certification procedure. We say our goodbyes, and I privately hope that he makes his phone call, telling the board that in the paperwork he found a responsibility of theirs that they don’t seem to be filling.

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> Professional ethics codes often position the individual practitioner as the primary locus of ethical responsibility. Individuals are asked to take the brunt of ethical conflict and adjudicate between potentially conflicting or incommensurate values.
> —Stark and Hoffman 2019, footnote 7

In observing what, on any given year, has become part of the engineering society's ethics codes, I have sought to explore what transforms a typical experience into an ethical question in a given community. In 2014, Zigon and Throop asked: “What varieties of experience are deemed to be morally/ethically relevant by social actors in communities of practice? (2).” Public political engagement regarding (in)appropriate technology is not a universal ethical mandate. Were there, indeed, any ethical questions related to (in)appropriate technology for the Australian engineering community as I accessed it?
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In beginning my inquiry, I assumed that the codified documents would be a window into the reasoning by which it was ethically viable for my interlocutors to allow the flourishing of what they privately perceived as deeply misguided technological projects,[21] even while cultivating public positions of knowledge-based authority regarding energy technology. I took codes as a cultural object that attempt to stitch together personal, subjective experiences on the one hand, with institutionalized, normative patterns on the other. I still subscribe to this interpretation, and I still also see them as a project of standardization that does not disavow ethical multiplicity, but attempts to coexist with it. The use of this archive has had its limitations and does not seem to provide evidence about how technologies are apprehended for the relevant "macroethics" they are part of (Herkert 2009); nevertheless, the "microethics" or practitioner behavior (Herkert 2009) they do address gives some insight into why technologies were not openly critiqued during my fieldwork. In ending my inquiry, I no longer assume the codes have much place in recording or shaping ethico-moral "experience" by "monadic, isolated individuals" (Zigon and Throop 2010:9). I have studied them as intersubjective, durable, political, and economic phenomena that have contributed over time to protecting practitioners from having to share their status as knowledge-based technological workers with others. Now that function is not left to the codes alone. As I observed with Andrew, writing about the ethics code in relation to one's own work is now an essential part of the certification process by which practitioners can gain a credential, CPEng, which is meant to give them, as per its advertising campaign, "respect in 8 milimetres" for personal distinction. The ultimate weight of the

[21] Andrew, in an unguarded moment, once expressed to me that he thinks carbon capture and storage is "a worse technology than nuclear energy!" Australia has no nuclear energy for electric power purposes, so this is a strong rejection. But it was not meant to be publicly associated with his name.

exclusion and foreclosure exerted by codified ethics is not the exclusion and foreclosure of "bad behavior." It is the exclusion and foreclosure of challenges to the reputations of elites and corporate persons.

Fractures

> I am volunteering at a meeting of a sustainability section of the engineering association, passing out nametags to attendees as a way of bartering a free entry fee from the meeting specialists who are ensuring a smoothly-running event. All of a sudden, protestors invade the sustainable engineering section committee meeting of the engineering association while I stand there as a volunteer at the registration desk. There are about eight, in colorful casual clothes distinguishable from the drab business outfits of the meeting attendees. They have their hands full of fliers and wish to leave the fliers on the seats of the participants in the sustainable engineering conference because one of the speakers hails from a company that is building a rail line to a climate-damaging coal mine in Queensland, and they think that his company "should not be allowed to speak about sustainable engineering." However, the man serving in the role of Conference Chair hears the commotion at the front desk, emerges from the meeting space, rounds the protestors up and sends them away, his low voice booming across the room.
>
> Later that same evening at dinner, the exact same man, the Conference Chair, grabs the microphone during the "toasts" phase of the conference banquet and makes an extended speech about how the association "must make a stand" about anthropogenic climate change. However, he is met with awkward silence and essentially ignored. "There's a time and a place," says the man sitting across from me at my assigned table, as a way of breaking the ensuing silence and returning the dinner table to normal conversation.
>
> –Fieldnotes, 2017

This chapter has given an ethnographic description of how "engineering ethics" is enacted through the national engineering association and its certification regimes. I have endeavored to situate "engineering ethics" within a historical class conflict over the conditions of recognizing technological expertise. I find that the Australians are concentrating ethico-moral authority in the hands of their arguably most wealthy technological-expert practitioners via the certification process for attaining engineering postnominals. "Ethics as etiquette," as I have characterized the ethics codes, has not been able to easily stretch to accommodate appropriate or contested technology and industries, since would-be reformers can become pre-emptively excluded by the very norms of care and concern they would seek to expand. Because of the non-transparency of the process by which engineering ethics codes are (re)created—and the associated unclarity nonparticipating "community members" experience concerning how some technological event becomes consequential enough that it inspires enough large-scale social criticism of engineers to motivate a change—it seems very possible that the codes are changing over time without any direct relationship to whether Australian society is critical of particular technological work or not.

Having studied the "ethics codes"—artifacts that name themselves as ethics-related but do not appear to relate too closely to everyday workplace and life experience for most practitioners (insofar as the number of energy experts not participating in the engineering association is vastly greater than those who do, among other reasons)—the next move for this dissertation will be to study how ordinary workplace life is ethically and epistemologically configured by the structure of the businesses in which carbon engineers work.

CHAPTER 4: THE BOX
Epistemic Limitation, "Research Engineer" Subjects, and How A Sponsor's Problem Becomes Generalized

Prior chapters have studied how professional ethics codes (Chapter.3) and financially consequential representations of clean technology (Chapter 2) configure the category of "responsible engineering." This chapter in turn explores how conceptualizing "responsibility" for knowing and doing requires delineating responsibility's *limits*, and how those experiences of limitation are shaped: epistemically, ethically, and by institutional structures. First, I examine archives from former engineering leader Brian Lloyd, as well as memories of changes within an engineering research organization I call Fire Sciences Limited, in order to extend Chapter 1's story of electric energy's privatization and highlight its conceptual relocation of an "energy expert" that precedes the advent of Australian CCS. Second, I explore today's conditions of engineering thinking, working, and ethical reasoning through an interlocutor's concept of "the box." Although it is just one person's concept, historical information and a series of "exhibits" drawn from fieldnotes expand it, demonstrating resonances across different instances of ethical and epistemic limitation and the ways in which engineering workplaces have required it. Lastly, I introduce three research engineers, portraying what it is like to be a knowledge worker on contested energy technologies, and what sort of relationships to those technologies are celebrated and allowed.

De-Engineering

Melbourne, August 2015: A visibly diverse collection of people, formally dressed, sit on matching gray and red plastic chairs in a small conference room. I sit in the back left row, quickly jotting notes about an evening question-and-answer-session at the engineering professional association's office. A panel of staffers or volunteers have recently finished a presentation on behalf of the association in which they explained how engineers in the audience could personally benefit from voluntarily participating in its branded credentialing and certification process[1]. Questions follow, particularly about the submission process for evidence of one's experiences and abilities for review. A woman with a head covering at the end of the aisle speaks up.

"This may be a question for Engineers Australia, not the panel," she says, but "Engineering as an industry: your technical roles are leaking overseas." What is the future of this credential, when engineers are not able to acquire requisite skills? "Do we need more dialog with industry?"

A man speaks up—one of the panelists. "I have two answers. You can go down a technical or a management path. The management path, we have the College of Leadership and Management. The technical path, the process [may need work.]" Although I do not catch the end of his answer, he seems to at least partially agree with the questioner's reasoning..

The female panelist from the water industry also answers: "My thoughts are: we can't send everything overseas. Regardless of [. . .] I work for Melbourne Water. There is no way we could send all of our designs offshore."

The woman who had asked the prior question leaves the meeting.

Another question for the panelists followed: "I just do simil-modeling. I see myself to have much difficulty of having the variety of experiences needed for these reports. Also because I am a contractor; because I am Asian, they might say to stay in this role, you're good at it."

[1] I discussed this credential with many, and I allude to it at the end of chapter 3. Years later, a reservoir engineer would summarize its meaning to me as "like a peer-review on an individual."

A panelist responds: “This process is about a conversation with your employer and their willingness to support your development.” Sidestepping the concern that some employers do not behave fairly, and even behave in obviously racialized ways, the panelist conveys that pursuing the credential in any case “starts a powerful conversation with your employer—that you are thinking about your career holistically. That you have got a very clear view of your career.”

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“My background is very much looking at the engineering profession as a whole.” This man works in accreditation now, through the Association, and considers himself to be in an intellectual relationship with the changing nature of many fields at once. His contacts have directed me to him as the “guru” in his domain of practice.

“I look across all of the engineering disciplines; the <u>ontology</u> of the profession; the difference between engineering and science.” He is happy to speak with me, as long as I would please not ask for or report any of his views about individual universities.

“I used to teach for a while as well,” he says. As a teacher, he would frequently make the following joke: “I am an aeronautical engineer, but I would never fly in an airplane I had built. But I would fly in an airplane I had *designed*. Engineers make the information: design is making information. To *act* is to *practice*—engineering is an information profession. Contrary to what is the popular view, engineers do not make things. We make information that enables other skilled people to make things. Approving information for others to act on is itself the act of engineering.”

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At these public events, I caught fleeting glimpses of how professionals perceived their prospects and agency, as well as encountered conceptual declarations such as the above. I also met members of the engineering public. Andrew, introduced in chapter 3, connected me via email with Mick, a member of this public who could sympathize with my challenges accessing prior Association reports and records. Andrew's reasoning seemed to be that Mick frequently sent freedom of information requests to the Australian government about procurement processes that affected his lines of work, and my interest in archival Association information was ultimately comparable to Mick's interest in knowing whether the Defense Department was engaging in nepotism rather than considering his submitted proposals for jobs he desired. Perhaps Andrew reasoned that since I was the only one who sought such access, I must have had a private and idiosyncratic interest, perhaps a search for scandal.

Mick repeatedly suggested that I read some of the writings of Brian Lloyd. According to the state library's records, Lloyd was a prolific author who had written or co-written thirty-four works on the history and sociology of Australian engineering professions. Yet Lloyd's last work, *Engineering in Australia: A Profession Debased*, appears to have been erased from his public profile as an author: it was not available at the library, and never mentioned by the Association. Improbably, Mick had somehow recovered it as a digital file. Having read *Debased* (2011), he seemed to think that it would help me understand how the association had "gone wrong" in recent years.

In contrast to these expectations, I found Lloyd's politics and interests in no way aligned with mine. The "debasement" he sought to portray was the admission of professionals with less than four years of university education into the Association. In 2011, against a backdrop of their own declining membership base from 78% of the "professional engineering labor force"[2] in 1919

[2] The calculations by which this population, acronymed "PELF," have been defined are an original creation by Lloyd and his co-author, and are too complex to repeat here.

to 20% in 2009, the Association began to re-admit the "subprofessional" practitioners rendered ineligible for membership since the definition of Professional Engineer began to conceptually shrink[3]. As he recounts the story of what he considers the sordid bureaucratic events leading up to the Association's "Ballot of 2010," which considered whether to admit "sub-professionals" (2011), Lloyd rails against this proposal, arguing that it would misrepresent the "sub-professionals" as engineers and thereby threaten the status and honor of those members Lloyd considered real, authentic, unquestionably "professional" engineers. Yet Lloyd also maintained a less classist and more fine-grained analytical concern that threaded through his works: a personal diagnosis of the ramifications of business restructurings and changing social evaluations of expertise for his cohort of peers.

Lloyd remembers that an engineering degree was once assumed to certify appropriate training for work in engineering management, but that was no longer the case as of 1991: companies who did engineering work were shedding engineers from their management hierarchy and replacing them with people who had professionalized in executive or commercial knowledge fields (alone). He coined a new term for his observation:

> De-engineering is the managerial approach whereby engineers are replaced in the *management and leadership of professional engineering functions* by non-engineers. De-engineering does not relate to general management roles not having a need for engineering qualifications. (Lloyd 2011:11).

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[3] As argued in the chapter "Codified Ethics," this contraction in meaning emerged slowly from the origin of the Association until the 1960s, and more rapidly after accreditation by panel visits, which began in 1963. I ultimately contend that the definition slowly narrowed; then the membership base emerged as too small to financially sustain the Association, and people named non-professionals were invited after 2010 to pay membership fees at lower tiers and ranks of membership. Lloyd however rejected the notion that lower tiers of membership should be allowed.

With these two sentences, Lloyd circumscribes the concept he has sketched across several of his publications since 1991—conceding by the second sentence that although "general management roles" do exist, managers have not only taken them, but have *also* taken over "professional engineering functions," which in his view they should not have. The fact that Lloyd felt the need to declare this a social problem in his milieu suggests that the status of technological expertise was being rearranged relative to generalist "business" expertise: technological expertise no longer seemed to automatically confer intramural authority or irreplaceability.

The "de-engineering," if it occurred[4], would have affected at least the intellectual composition of management groups overseeing engineering-intensive companies or projects. Moreover, it could have affected workplaces' technological preferences, as such preferences would now be subject to review by people who had never trained in any engineering school or apprenticeship but instead had come from management education. Lloyd had an opinion about that: "The technology engineers use and the matter of its application must, by their nature, be determined by the engineers themselves. These are essential elements of the roles of managing engineers" (Lloyd 1991:16). The fact that Lloyd had to explicitly state this claim to authority over technology strongly suggests that he felt it to be threatened. Furthermore, Lloyd believed that once non-engineers came to hold "ownership or control," different decisions would be made on engineering project sites, with consequences for the built environment and the ambiguous

[4] Determining how broadly or narrowly de-engineering occurred is not ethnographically accessible, because this could only be measured by speaking to executives or former executives (difficult) of a wider-range of engineering-related companies than this already-broad dissertation is scoped to include (nearly impossible). Yet historian Brian Carroll corroborates this trend: "In 1986, twenty-two of the chief executives of the fifty largest companies in Australia held engineering qualifications." (Carroll 1988:234). Carroll similarly feared this proportion was failing, with negative consequences.

term of “public practice,” which may in fact mean something conceptually similar to “public service” as an ideal:

> Members of the profession cannot offer to provide public practice through regular for-profit corporations that are not controlled by members of the Profession. Instead, collective practice must be in the form of partnerships or professional corporations, with prohibitions on ownership or control by nonprofessionals. Practice as an employee must include recognition of the professional autonomy of the decisions of the professional employee. (2011:9)

Loss of autonomy to pursue the best technological provision for social needs, subjection to “business” priorities—the process of de-engineering emerges conceptually as something that not only leaders like Lloyd, but also any given engineer would have experienced. Mick’s framing of Lloyd supports this.

From atop a windy hill, Mick took a break from his weekend hobby of hang-gliding for a phone interview with me. A mid-level professional in his 40s[5], he had cancelled his association membership in the early 2000s, feeling that processes he did not know how to name were “commoditizing the intellectual worker” into an “underclass.” He felt the Association was not helping, although, “in the ‘60s and ‘70s, it had great value.” Like Lloyd, Mick had apparently become uneasy over time with whether their organization was ultimately serving them, or merely witnessing their processes of loss: of opportunity, status, and importance within large organizations. “Read the Brian Lloyd. In the 1990s, it [the Association] lost its focus—allegedly.” Mick asserts that the association has accepted de-engineering and has idly stood by

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[5] I appreciate Mick’s aphoristic observations. Regarding his own education, he offers: “Engineers do not have the ability to generate context.” Mick is grateful that a teacher once made him read a book entitled ,*Time, Space, and the Making of Place,* which gave him a starting vocabulary for what he calls generating context, unlike his peers who have never been invited to learn such things: “We just wander around like a sharp knife, hurting people.” Regarding my position as a researcher: “You don’t have a paymaster. You can afford to bite the hand that does not feed you.”

while technological experts such as himself have become interchangeable and subordinate to non-expert management.

Lloyd and Mick share a perception of two facets to this process of “de-engineering.” First, they perceive engineers to be losing management status to a new stratum now situated “above” them. Second, engineers simultaneously merge with a second stratum imagined to exist “below” them (Mick calls these “the two and three year guys,” referring to the imagined length of University education; echoing Lloyd and other Association leaders’ politics of exclusion). Mick thinks that Lloyd’s account, “minus the personal opinions,” becomes a narrative of “infrastructure decay in Australia,” implicitly considering the professional association a piece of infrastructure whose ability to serve people like him is waning.

Recall how the Association’s panel responded to the questioners as described in the opening of this section: a woman concerned that she would not be able to gain documentable technological skills in a country that actively offshored technological work was told that she could instead join “the College of Leadership and Management,” and a man concerned with racializing discrimination by employers was advised to pay for the Association’s credential anyway in order to improve his professional self-presentation; one of few factors within his control. Considering these responses, the unclear membership base[6] and unclear politics of Lloyd’s association circa the “Ballot of 2010” appears to constitute the grounds for the emergence of intensified credentialing, certification, and stratification processes as witnessed in 2015. Somewhere between Lloyd’s 1991 publication and my 2015 observation of the evening panel discussion, Lloyd’s sharp concerns and would-be whistleblowing seem to have lost their

[6] Compare also a comment from an interview in 2017: “The word ‘engineering’ is not used in my organization. People are grouped on function they perform: consulting, services, operating, managed services, account team.”

urgency. More specifically, his worries that Association membership was becoming decoupled from four-year collegiate accreditation, while people with four-year degrees yet without dedicated “management” training lost access to management roles, have dampened. During this period, the social fact that having technological knowledge places a worker in a subordinate role to a professional manager appears to have become naturalized.

Fire Sciences Limited (FSL)

The first time I heard FSL mentioned in a public meeting, they sounded like just one among innumerable contracting firms with acronyms for names. A presenter explained: “We are not scientists; we engage FSL Technologies to validate” materials science questions. However, this organization had been freely and frequently mentioned in private communications. The FSL was folded into narratives of downsizing, yet this was characterized as a “scientific” loss paralleling the forfeiture of training and work opportunities: “The SEC-V had a huge investment in science of coal and did a lot of good work—most was lost in the privatization process.” But what exactly was lost, how, and by whom, was more complex.

FSL began as the in-house research laboratory of the Australian public electric power industry. In the change of institutional structure, one of my interviewees who “started in power station construction” and “never worked for one of the old entities” describes the logic of the privatization as:

> ‘Let’s be good at our core business,’ people thought. Maintenance, engineering and technical services, contracted out. Those facilities, did not get kept. ‘Hire them back.’ Consultancies got those people. [Now today, for example,] the man who knows about the cooling towers: he is 86 and retired. It is getting harder to gain that information. As a consultant, I have been amazed by what people will pay me to answer. [. . .] The people crisis is on us: prices are high, supply is problematic, fuel poverty is happening where fixed-income families pay more than 10% of their disposable income.

> [Now,] FSL is a private company. They were the repository of most of the knowledge. About 2.5 years ago, they went into liquidation. Hard to make a living as a research company. They had to transform themselves into a consultancy. Most of the fundamental research got shelved. Shareholders, FSL couldn't justify it to them.

Another energy expert, reflecting on the institutional locations of advanced fossil energy research across his career, remembers that "FSL went broke under private ownership," despite the company's endeavors to create a business of testing and assessing materials. "One person bought the company." All of these accounts are slightly different.

It was a while until I met anyone who had directly worked for FSL, but eventually I became able to I ask a former worker of the Coal Science Division of FSL to tell me about "what got lost" over time.

> There is much less hands-on practical work. Paper-based and computer-based [engineers] come in—they have two left hands. All of the very sophisticated computer modelings have come in. Empirical methodologies moved to theoretical modeling. [. . .]
> We as an R&D arm were trying to develop this advance power gen technology. We decided we wanted to buy the business out. In 1994, 80% of the staff of the business bought stakes in it, creating an organization of 900 people with 30 subsidiaries. The provision of technical services served as a means of retaining IP and knowledge—to hone those skills on our customers. Very innovative, very driven—such incredibly clever and dedicated people—they are really nice people, the culture. I took a share. [. . .]
> We came within a few weeks of locking in power take agreements. Groundbreaking technologies in coal drying. We finished the pilot scale in 1998, spent next 15 years trying to get the project p. Problem is, we invented the technology 15 years too soon. Any new technology needs to be underpinned by government incentives. It would have been better if Australia had locked in a carbon price. Governments have tried to <u>pick winners</u>—Tony Abbott's been cycling [through the Latrobe Valley] to influence [a diversified energy company] to sell [a coal electricity station]. The market should be allowed to decide. Subsidies to drive change.
> We also bought one of the old power stations and briquetting places. [. . . .] We ran a power production and briquette production facility. Conventional technology, provided profit and cash flows and hands-on credibility. [But that facility] used to lose 50 million a year.
> The image of excellence: always to look at the new innovative technology—to improve efficiency to improve economy to help underpin Australian prosperity.

> To achieve that we purchased a related entity in the power business. Have bought the business for its cash flows. It eventually had its demise. [. . .] We used to be occupying a larger space. 460 million of investment in gasification technology processes. All that IP will revert back to the government ultimately.

This narrator is caught between two languages for how the state can support research and technological change in advanced fossil energy. Although he believes that "the market should drive change," he also believes that the government should intervene through subsidies. He is left thinking that the advanced power stations he and his colleagues designed had been merely out of place in time, and out of place in trying to reduce emissions without a carbon price, leaving their pollution control technologies stranded as too expensive amidst a market of unabated and thereby cheaper opportunities.

Regarding what his job looks like in daily life, he offered:

> Three days of the week, I keep the gray cells ticking on. With the demise of the previous company, I help 70-80 people keep their jobs. I have been assisting management teams to help in marketing and business development. The company has stabilized, and is growing. A mentor for the guys here. I ran the sales meeting for key business managers. A meeting with [a brown coal worker] who wanted research work done—I travel widely. [. . . FSL now is] not a research company. 90% is consulting and testing services. There is not enough research work. 'Tactical research,' if you think you are going to have money. [. . .] I spent half a day walking and talking to people in this building. [. . .] Part of what I do is coach the management team. Getting them to ask open questions and to listen. The hardest thing to get them to do is to get time to talk to people in very open ways.

You Take the Box Off Their Problem

I had been looking forward to the weekend, as Evelyn had invited me over for dinner on Sunday at her boyfriend Ted's house. A solid friend whom I had made very soon after arriving to downtown Munich, Evelyn was eager to introduce me to Ted, an Australian civil engineer equipped to discuss carbon engineering from an informed point of view. Ted did not mind that I wanted to tape our conversation, which began with the metal-on-metal sound of a knife being sharpened in the background. Flanked by a large bottle of Maker's Mark American whiskey and a glass with ice by his side, Ted began with some insights into why "engineers are, as a group, probably skeptical of the social sciences." As he had framed it more provocatively on a prior untaped encounter, he had some insight to convey about why everyone probably hated me, he assumed, at my internship in a CCS research organization.

> To go back a step, the whole point of engineering is creating a box of conditions and parameters in which you know your problem—ah, eh, uh, at least of parameters, conditions, assumptions, which you know that the particular set of circumstances you are designing for sit within. So, no engineer really knows (pause) the actual answer, but we know that the answer only exists within this sort of bounding box. And depending on the level of safety and how critical it is, and the cost implications, we either make the box bigger or smaller, and therefore the design more rigorous, accordingly. So, so, when you think about engineers, that have this real fundamental that has been drilled into them for years, that each problem can be disassociate---uh, not disassociated. Can be *condensed* into a series of smaller problems, each of which has a very rigid set of assumptions associated with it, then if you are trying to plan a sort of methodology to the problems you encounter as a social scientist, the general consensus is that, that it is not as rigorous or onerous, and while you can have rules that apply in some circumstances, then for no real reason, they apply to others.

Ted argues that "the field you are trying to do your work in, you're at an innate disadvantage, because most engineers would be skeptical to come talk to you." I change the subject here, and try to instead understand whether his workplace experience included having the sense that he should refrain from discussing the political implications he perceived technologies to have:

> At the end of the day, you hire an engineer as a consultant to solve a problem that you have within a certain amount of timeframes and monetary constraints. So if you as an engineer have a political or social view that restricts the type of work you are willing to take, well of course that will affect your, your, um, social mobility, your working mobility. Ah, um, I think that that question answers itself.

Yet Ted does not directly agree with my subsequent provocation that "being morally flexible is a career asset?" Instead he points out that there is a temporal dimension:

> By the time they have been given the job, all of the decisionary [sic] and social and political, that may go into making—that may go into influencing your client

> into a different technology rather than fracking—has already occurred. So literally the only thing the engineer could do is say that I refuse to work on this job that my boss has given me. Now what engineers *could* do, is they could say that fracking as a *concept* I disagree with, so let's try to create other engineering ways that we can achieve the same outcomes, in terms of energy. But that all has to be able to be driven at a much higher level than a design engineer would ever be able to influence.

"So can you tell me about the higher level?"

"It's the client!" Ted stages the image of an oil and gas company that has bought land from which they seek to extract oil. "An engineer really has no control over what is going on at the macro-level." (I eventually stop taping.)

Ted serves me roasted lamb; a pilaf of grains, leaves, and seeds; and crisp steamed broccoli and peas, doused with something he mixes up in a Mason jar: a little olive oil, some marinated onions, presumably vinegar or lemon: "Cut the fat," he explained, in order to manage the taste of the food. He sat on the sofa, still drinking whiskey. Evelyn sat on a different sofa sectional, silently. I took out my notebook, as Ted seemed to enjoy the spotlight as he spun provocative phrasings into the air.

As the evening wore on, Ted later expressed that if employees were being polite in a workplace rather than giving me disrespectful nicknames, that means that they probably considered me an enemy. "They all hate you. Your questions are leading questions. Your informed consent information is all wrong." His whiskey glass had accompanied him to the sofa. I imagined that with his provocative remarks, Ted was trying to demonstrate the generalization he had made about what Australians look like when they are being sincerely friendly. I was determined to get him to define "the box" again, so I asked if I could please turn my tape recorder back on, first repeating what I thought he had said.

Ted: "The way you just defined the box was—what?"

Me: A social decision?

Ted: “Yeah, a construct. It’s a construct, that’s made.”

Me: Some people defined the box, they gave it to you--?

> Ted: Yeah, yeah. [Voicing a socal scientist:] And why does it exist this way? Which might not necessarily be true? YES. In social sciences, that’s absolutely correct [as a way to think.] In engineering, that’s the exact opposite of everything you are trained to do. Because what you need to do in engineering is: you need to create a rigid set of assumptions and constraints within which your answer—which in all engineering, should be the drawings you produce, because in all engineering that is all you can ever be evaluated on should be correct, because, you know, drawings get sent out and there are two to three pages of writing on those drawings. Because those writings will tell you what concrete, what cover, what reinforcement, what steel grade; where that needs to come from, the welding, blah blah blah. So within this rigid box, the answer I am giving you is true. And that is the fundamental difference between social sciences and natural science which I believe engineering is the application of.
>
> As soon as you start making the, the, the construct of a box in which you are thinking about your problem, you start making that <u>malleable</u>, that fundamentally contradicts everything you have been taught to do, which is to make that box as rigid as possible. Because only within a rigid box are we able to fully mitigate the risk or identify and evaluate and take that risk and put it onto someone else. So we are saying that within that set of parameters, my answer, or my set of engineering drawings, is valid. It is your responsibility to make sure that assumption A is right, assumption B is right, that it is manufactured in a certain way, blah blah blah blah blah.

I replied that I think I understood and snapped off the tape, annotating in my notebook that Ted continued: “Without the box it is impossible to have a correct answer. Without a list of assumptions and design criteria—” Ted sketched an outline of a box on a page in my notebook and scrawled within it “correct answer.”

The first obvious meaning of the box is epistemic: it signals that something is correct. The “pages of writing on those drawings” exist outside of the box yet remain attached to it; they are old knowledge—which the engineer is not responsible for—that nevertheless *attaches* to the new knowledge—which the engineer is responsible for—in the form of the box’s contents. What is in the box is the answer, the question to which was given at the moment of an engineer's hiring to meet a client's need, framed as a question seeking an answer. The first step in thinking and answering is to create the box. If the box is unclear—as the figured social scientist Ted discursively creates would point out—then the first step has not been completed and thinking is impossible. Later in the chapter, I will discuss some further implications and appearances of "the box" as an epistemic technology.

Notice that in Ted's last sentence, "the box" is also an ethical technology—a means of constructing and attributing responsibility. When he shifts from discussing "my" to "your," he addresses the boundary between the engineering self and the associated institution or organization : "within that set of parameters, my answer, or my set of engineering drawings, is valid. It is your responsibility to make sure that assumption A is right." Here Ted refers to an imagined contract drawn up in the exchange of drawings with an employer of any kind: the conditions met in the "writings" attached to the drawing and hence external-yet-attached to the box, must by met by the employer who will simultaneously be purchasing, likely through other professional agents, materials such as steels and pipes and machine components as exactly described in the writings. Failure to comply with such specifications is to depart from the assumptions that configure the box, and hence epistemically invalidate the accuracy of the box's contents. At the same time, responsibility for possible technological failures pours outwards, away from the design itself, which would have been correct had its "writings" been obeyed, and towards any employer or their agents who attempted to use the design without doing the work of ensuring compliance with the materials and conditions listed in the attached writings.

As the evening proceeds and he continues to enjoy his whiskey, Ted returns to another ethical valence of "the box": choices among workplaces: "When you can't control the box, it's a job you don't want to do." You don't want to do the job because by doing it, you become professionally and legally liable for something larger than you can control. This is implicit in his next explanation: "The engineering signoff: listing all the assumptions, all of the codes. I have put my name to say it will work." Signing off means that "I am willing to say that what I do conforms to this standard and will be fit-for-purpose. Given X, Y, and Z, what I do has been this." Ted eventually swings back to express the negative effects of "signing off," which I have heard through Evelyn is causing him considerable professional angst at the moment, since he may have signed off on a crane or a load that later fell onto a covered walkway. "They just want to pay you a nominal amount of money to make you do something that will take the risk—off, away from them."

I will address some further implications of the box as an ethical technology later in the chapter. Ted framed his stances on knowledge and responsibility within the question of potentially divergent epistemologies between me and people at my carbon storage research internship; a position which Ted merely imagines, and has no concrete awareness of or relationship to. Yet while voicing "them," he warns that, "devaluation of social sciences and arts may be a side effect of how you have to think to do your job." Interestingly such devaluation is *not* a side effect of the financial and service loyalties involved with selling expertise, but is instead a function of the modes of knowledge themselves. In other words, Ted presents box-drawing as the *only* way to obtain "a correct answer;" a necessary prerequisite to reason and knowledge. Further, he speculates that my research participants must hate me because "you take the box off their problem." This means that either my own thinking, or my lines of questioning, or the forms of knowledge that I as a figure represent, call into awareness the artificial or constructed nature of an engineer's "box"—thus both taking them back to a prior moment in their experiential relationship with their workplaces—prior to the possibility of logic and accuracy—and also reminding them of the political economy of questions and answers in which they work. Neither of these revelations would be welcome in an ordinary workday moment.

Carbon engineering, Ben goes on to say, is a very political topic. Regarding my participants, I should assume that “carbon storage is just their job at the moment. Also, “research” is a term not only for something with potential, but also for something with contingency: “if it did stack up economically it would be happening” beyond the walls of their research organization as well as within it. But regarding the price of carbon engineering, he does not think it should be taken to reflect badly upon the prospective technology: “The sunk cost in what we have done is very great. Thirty or forty years ago we gave the same help to oil and gas.”

Exhibits: “The Box” as an Epistemic Technology

1. Internship fieldnotes, 2017: She hears me talking in the kitchen, in response to someone’s friendly inquiry about how my project is going. “Put some boundaries around the project,” is her advice.
2. CCS industry employee, May 2017: “Every technical project has a social component. Social license, socials, engineering, project management. They can allocate the social component to others.”
3. At a research conference, I ask a man from Geoscience Australia and another from the Global CCS Institute: “How do you get your head around all the different topics?” “You don’t,” they say. One continues: “You have to trust your people. I was sitting right next to an absorption engineer during a presentation on PSA and he did not know more that superficially what was going on.”
4. February 2018, carbon storage opposition group meeting fieldnotes: Tom sits next to me, hears that I have been engaging with members of the industry. About how the government employee I met at a coal conference wants to see my publications after I write them, he interjects: “That’s a good story. They don’t know themselves!” He also asks me whether the engineers say the retrofit of the technology is feasible? I tell him that I have mainly engaged with oil and gas and have not been in touch with the coal side.

5. Internship fieldnotes, 2017: "I ask her what's on for the day and she says she will need to call some suppliers, not customers, if that makes any sense (I say it does) to ask them about their scope of work and confirm what is in it."
6. Preliminary fieldwork notes, 2014: "[The coal seam gas joint venture] is one big engineering project. Meaning that we each only know what is going on in our little area."

The combination of these exhibits across place and time is a provocation. A successful knowledge project is assumed to require boxing-in (1). Multi-company and multi-expertise collaboration in an "engineering project" is implied to required defined scopes of work, scopes of knowledge, and scopes of non-knowledge (2, 5, 6). These dynamics may touch the carbon research community by separating investigators from one another (3), as well as separating government funders from contextual and historical knowledge about the carbon research they are supporting (4). Notably, none of these constructs relate to institutional and corporate privacy alone, but rather at least potentially relate to the (discipline-specific) epistemic requisites of the work.

Exhibits: "The Box" as an Ethical Technology

1. At "lessons learned" meeting on multicompany collaboration to build a coal seam gas pipeline, Queensland, 2013: "That was always an issue: 'What counts as direct supervision?' It was a *necessity* to go to China. People have lost their jobs for signing off for things done in Townsville if they're based in Brisbane."
2. PhD student from the Climate and Energy College, introducing herself to a Melbourne University reading group meeting, May 2018. "I work on the adaptation side. It is always premised for me on the assumption that other people are working very hard on the mitigation side."
3. Junior electrical energy engineer, interviewed regarding what credibility to sources of energy engineering information, 2018: "We have to hire third parties so that there aren't conflicts of interest. [. . .] That third party report is what we present to the regulator."
4. Senior electrical energy engineer, interviewed regarding what historical changes he has seen since the 1980s in his professional milieu: "SEC-V was a technically

excellent organization. It was now commercially excellent. Do things technically proficiently, to near enough is good enough. Best possible quality: we didn't have inspectors. Now moving into a privatized world, we had a 'quality journey' to go through. SEC-V had the best quality. All of that was lost. Technical excellence, to commercial backed up by technical excellence. SEC-V was built on families, cousins, aunties, uncles. The other thing that stopped was training programs for apprentices, etc. Disappearing a lot of baggage from industry—where they ended up, I don't know."

5. Fieldnotes, 2017: The energy policy analyst's morning was busy because there is a bill before Parliament. I must have heard of it. No? I haven't? It is about the Clean Energy Finance Corporation and whether to remove the prohibition on Carbon Capture and Storage receiving CEFC investment. "Judging by how this institution has gone in the past," we will write in support of it, he says, where "we" means his employer. Since his daily work includes writing, it probably means he will be doing the actual writing. "We are also pro-nuclear energy and we are technology-neutral all of the way," he says, walking past me to put away his cup and get back to work beyond my prying eyes.
6. October 2017 fieldnotes: I take the moment to ask the research worker about a prior conversation we had had regarding CO2 going into the ocean: "You said something like 'CO2 inevitably goes into an ocean,'" I ask. "I never said the word 'inevitably,'" her responds, then pauses. "We need to be ready to act in a worst case scenario. It is something that we should be doing so that if CO2 is detected in an environment, we can say it is *not ours*."

Again, a provocation: these exhibits explore strange possible configurations of responsibility that attend accepting a client's "box," or presentation of the problem, filling in the solution and attaching written conditions. Multi-corporate networks foreground the concern about whether one knowledge worker can accept responsibility for checking another knowledge worker's creation across international distances (1). People and their flourishing (4) can be defined as separate from the success that an organization asks its knowledge worker to attain. Environmental damage becomes not the problem knowledge workers are asked to fix but rather the assigned target of work (6). Experts perceived as a third party can, in practice, participate in a technological project based on the decisions of those whom they are meant to neutrally evaluate (3), or require conformity to policy preferences that are pre-set (5). Finally, knowledge workers can devote their attention to what they knowingly understand to be partial problems, hoping and expecting that institutions are delegating other components to others, without knowing whether this is in fact true (2).

"Energy industries" cross and smudge many types of boundary that could be imagined as existing between disciplines, forms of knowledge, and people; hence they are compelling sites for the study of how disciplinarity is conceptualized and enacted. In what remains of this chapter, I explore what it means to identify as a "research engineer" at the intersection of making or remaking *things* (i.e., crafting, constructing, assembling) and making or remaking *information* (i.e., scientifically knowing, managing)—particularly by continuing to examine why "making information" has become an increasingly salient project for contemporary Australian engineers.

"Research Engineers?"

> Remark over lunch, CCS research conference, 2014: "These days a lot of engineers are becoming scientists. There is no funding from NSF to improve big plants."
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> Final moments of a conference on "Carbon Utilization," 2018: Many of the Australian CCS research managers had convened for a photograph. A conference administrator was handing out fliers, perhaps of another related conference planned for a future time. Over the multi-day event I had formed the impression that she seemed to have had an important guiding presence "backstage" in assembling the conference, by the set of conversations she had seemed to be included in across the gathering. Her situation as flier-distributor gave me the opportunity to approach her. "What is the breakdown of research v. industry at this conference?" I casually ask. 'That depends on what you call 'research,' she says."
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> Ali, power station engineer, 2018: "An industry problem is confined to a sector. A scientific problem would take into account impacts on the surroundings as well."
> Conversation at engineering professional association, 2015: "At CSIRO, one third of the researchers are engineers. There is not delimitation in that organization, just what is the right skillset for the project. We have an acquaintance who is a marine engineer there."

> Conversation at an industrial site, 2015: “We have a whole raft of engineers trying to think of new and better ways. Usually every time they do a different design, we claim it as a tax deduction because it’s R&D. I use all of the kinds of engineers, all the time. 14 of them are in the design group.”

“Engineering research” is a challenging category because the semantic range of each of the two terms, “engineering” and “research,” are already substantial. But the figure of the “research engineer” is not paradoxical in Australia, due to the ways in which science, engineering, “responsible” industry, and nation-building justify one another. Via ethnographic portraits of three interlocutors below, who work in both “research” and “engineering,” we can see that Australia’s historical normalization of “applied research” and consulting-to-industry-or-government legitimate academic domains, in other words basic to many academic lives, renders CCS a normal rather than a novel object of work.

Professor Zachmann

The professor is able to start our meeting early. From a large engineering department office furnished with a large meeting-table and peopled with an administrative assistant, he has just been working on a government report “on whether they should allow fracking in the Northern Territory.” He wants to check whether I understand the difference between CCS and fracking: “with fracking, they literally use *explosives*, but CCS never does.” He continues: CCS “has gone off the boil; five, ten years ago, there was more.” This professor spends roughly 50% of his time on administrative work, 40% on research, and 10% on teaching. He work for industry for five years; attained a PhD while raising a family; returned to industry for three years; and has spent nearly the past two decades at the school. The professor tells me about the type of research his laboratory conducts and the nature of the industrial problems it addresses, sprinkling in references to important moments in both political history and the history of technological tests.

CCS's "window has closed," the professor speculates, because "the cost of solar has dropped so down. The IEA, IPCC are out of date." Particularly with respect to costs, commissioned reports are less accurate than peer-reviewed literature.

The professor also does commissioned research. "I charge them three times my salary. That answer will be just given to them." His rate for collaborative research is 1.7 times his salary, and he normally asks, "to be able to publish the results." About accepting these industrial projects into the academic lab, he explains: "It is a constant battle to decide: is this a 'slant on my research'?" The approach he chooses is to evaluate a given technology, give an honest assessment, and publish this account. He explains further: "If the company is defining the problem, you know it will have impact."

Marc

At an evening meeting at an environmental NGO, volunteers and interested Melbournians gathered in a space that operates a vegan café and organic grocery store by day and becomes a wooden-floored, big-windowed meeting room by night. The meeting was convened to discuss volunteer opportunities related to Victoria's "energy transition." During introductions, a man with curly hair and a slightly sheepish air to him reveals that he is a technological researcher in CCS. I feel very grateful to later collect his email address and plan an interview because he is the only CCS research industry employee I have ever seen at an environmentally-themed event, other than those hosted in the Geology Department or main meeting halls of the University of Melbourne.

It is a long ride by public transportation to his workplace, where we have lunch. Marc explains that his professional range includes any work that ultimately reduces carbon. "I didn't look at all the technologies and choose carbon capture." He had studied chemistry in the UK, then taken up a study of artificial photosynthesis; completed one postdoc; and now had found a second postdoctoral role in Australia. “Our group is focused on reducing costs of operations.” Marc is not an engineer, nor did he learn about CCS from any textbook; rather he simply reviewed the literature and learned from his team members.

The CCS research industry, as Marc encountered it, was in a “general mood of depression.” He affirms that CCS “will be necessary” for decarbonization, and mentions the fact that it has industrial applications. CCS, he considers, is “stuck in the political loop. It is going to carry on at that glass ceiling level until regulatory circumstances change.” On a scientific level, he would consider it “siloed”: “People doing CCS talk to other people doing CCS.”

Regarding the difference between scientific and industrial problems, Marc says “A scientific problem is interesting in its own right; an industrial problem has money driving it.”

When I ask whether CCS is “green energy” or not, he wants to change the question: “Is it good to do—is it morally good?” One should ask: ‘Can it make a contribution without allowing additional damage to be done?’”   Research domains align with technological qualities; yet people make decisions economically. He considers CCS a worthy technology because “we are going to need it, refined and working. I think it is green.” Industries operate as they are currently because of:

> …the need of capital to make profit. It is not likely that a preference is included. My initial response was that this is just coal. [But then I learned that] the models that try to build a whole system energy grid are more expensive when they don’t use CCS. You want to use an optimized system. It is a ‘quote’ green option—green relative to oil production, mining, unabated coal.

Regarding carbon engineering’s use for enhanced oil recovery, however, Marc is opposed. Yet about the direction of the industry, “It is out of my hands. Anyone doing CCS with an environmental intention hopes to have a positive impact.”

Mila

I meet Mila at the Climate and Energy College[7]. Another PhD student, Annika, dressed in a blue pencil skirt and a watermelon-red top, lets me in. Annika greets me by name but I don't use hers; I feel a little embarrassed that I cannot exactly place her amid the many happy, healthy, alert young professionals who work there. I carry a gray backpack and also an embroidered purse decorated with cats; prepared for a train ride to the towns surrounding the power stations and an overnight stay. I offer a gift of several Lindt chocolates and a Ferrero Rocher in a plastic tub to my interviewee, who approaches, wearing a red tee shirt with a bicycle motif. "Is this your bribe?" Mila will later ask, and simply scoops up the plastic tub to take back to her desk. I exclaim: "Wait: the lid," and produce it from my backpack, in case she wants to re-use the container. Everything within the Climate and Energy College is decorated in pale wood, and there is a silver bell hanging near the door that a director rings whenever any of the PhD students "gets a publication."

I first encountered Mila through a random lunch at the college, to which I was invited by its only affiliated anthropology student. I speculated aloud about carbon engineering's historical dynamics, and Mila revealed that she used to work at an oil multinational adjacent to a CCS project in Europe. So before the interview, Mila has heard my opinion that anthropological research ethics are designed to protect people, not corporations. However, I tell her, in my training I have been instructed to minimize the use of corporate names, though sometimes this is impossible—as it was in the case of Dinah Rajak's book [. . .] "So let's just call your former employer Company X," I offer. Mila agrees, but does not reveal—as I had hoped—what, if any,

[7] I had tried to affiliate with the college in order to hasten the legalities of my fieldwork in Victoria, but an administrator said "We can't help you" immediately upon hearing of my ethnographic research methods.

confidentiality requirements are required of her. During the following conversation, details about the “five pillars” of a corporate strategy and how CCS fits into them, which she had initially described over that first lunch, are apparently off-limits now that I am taping. “She got really coy about this when I asked about historical facts,” I wrote in my fieldnote margins.

Among many other things reported here, I asked Mila to tell me about any moment in which she felt that she had really learned something about carbon engineering. She sketched a scene featuring a compelling picture in a meeting room:

> The meetings in Australia were with all technical people. The operator presented the model of subsurface. It all made sense to me. How you could visualize the pressure gradient. A visualization that helped me understand the process; A great learning product. It also highlighted the risks of CCS. The faults.

After our interview, I asked Mila—ignoring what were likely last-minute texts from my next interviewee requesting to reschedule—if I could please have the image that was part of her learning experience. She points out a problem with my request: “You are not allowed to take away data. When you leave, your emails—everybody does, but I am not allowed to have it.” I tell her I will email her about it another time if I really, truly need it. An unspoken question underpinned our exchange : “*What are you going to do with it?”* I’m not sure I offer an answer, but I try. I say that most of my data is like an iceberg under the surface, and only a small bit of it will be reported; she could assign whatever conditions regarding its use she wished. But none of this helps.

Post-interview, Mila is back at her desk, headphones on, Randall and several other men also sit at their desks, large headphones covering their ears. Annika is chatting with me about how she has a busy weekend coming up because her husband is Resident Head of the college and the new students are arriving. I get back to work attempting to print some materials at the college facilities: an email from a government worker from Canberra; the Earth Resources Department’s "contact us" page[8] on the state government website; and a senior colleague's dissertation, which is quite large. Mila and I are now chatting about sports as I wait for the prints. I eat a peanut butter and jelly sandwich out of a reused bag from the bulk natural foods store, slurp some water, and prepare to do another interview downtown.

I ask Mila, "Are you writing today?" I meant writing, but she hears "riding" and interprets "bicycles."

"Yes," she says, "do you ride?"

I tell her that I am living minimalistically at the moment and don't have a bike, but perhaps after I return to Chicago I'll take it up.

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> "Today, we all work for the same company." –Participant at a celebratory dinner after a CCS research conference

As privatization normalized the "extramural[9]" location of technological knowledge, the social process of diremption between "managerial" and "technological" expertise unrolled like a wave across energy experts' workplaces: reported upon, naturalized, and abetted by theoretical musings about "an information profession" like that of the accreditation worker. Engineering researchers in carbon and related fields were affected by this process, which had consequences for their problem-solving and their "responsibility." Specifically, it helped normalize a division between those who set up boxes and hire people to answer the problems stated therein (i.e.,

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[8] I received no replies to my emails from this department.

[9] By extramural, I mean the expertise was located outside the walls of its funders and the decision-makers who had the role of setting up problems for knowledge-workers to solve. For example, if the electric grid had a problem, a consultancy would need to be hired to determine the contours of the problem, and perhaps a different consultancy later to determine the best solution, and perhaps a third one to carry out that work. The people still "intramural" perhaps had the opportunity to think of themselves as experts in management itself, rather than in energy-related topical knowledges.
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managerial experts, who remained intramural to the governance, funding, and ultimate ownership of energy infrastructure), and the people who were hired to answer problems that had already been boxed, in other words defined (i.e., subject-matter experts, whose living was made explicitly through their technological knowledge, and who had become extramural to the locations of governance, funding, and ownership of energy technologies.)

This chapter's ultimate provocation is the possibility that many "research engineers" may not be experiencing their work much differently than any other vendor, supplier, or service specialist would. Although conceptually, "research" evokes a separate type of activity than any other work—one with creativity, agency, novelty, and independence—my findings question that assumption in three regards.

First, an expert professional may be given a "box" to solve within, just as any other form of engineering work could require. Be they PhD students, employees, contractors, consultants, or even full academic professors—no one seems immune from having the term's of one's engagement with a topic (i.e., the "box" of assumptions and parameters)—determined in advance by an investor, funder, or client. Increasingly, the experience of limitation appears shaped by the concepts of what knowledge is and what individual workers can expect to know, within large-group, collectively-created engineering projects, as well as current neoliberal conditions of precarious service provision and subcontracting. "The box" is an important concept because it is one person's description of how limitations to knowledge and responsibility are experienced as non-negotiable precondition to the very possibility of thought.

Secondly, projects may be tagged as "research" by their financial supporters in quite a range of situations, even just a search for tax benefits. Intellectual laborers working on such projects may not identify their roles as ultimately "scientific." Technological skillfulness serves industries whose job titles can be out of step with the experiences of their participants. Exemplifying both of these first two possibilities, the work of “testing” performed by Fire Sciences Limited shows the vast gray area of “engineering research,” as it could be used either to validate a newly-designed technology’s performance or alternatively for everyday monitoring and analysis. FSL’s employees may have considered themselves researchers while simultaneously adopting ordinary service-provision logics of practice and self-support in order to endure the decline of the public energy industry milieu in which their laboratory began. Or, they may have considered themselves service-providers, but ones engaged with clients who may have been researchers.

Third and finally: as jobs become increasingly precarious, knowledge workers may labor to solve problems that they do not identify as valuable or necessary, or that they do not identify with or feel drawn to in a vocational sense. This is my interpretation from Marc’s case.

In his ethnography of a public transit network being conceptualized and then abandoned, Latour (1996) observed that engineering workplaces have normalized a dense meshwork of contracting and subcontracting relationships as expected, everyday practice. Latour’s presentation of technological experts as ethnographic interlocutors highlights the limitations of what they comprehend and discuss, but he does not suggest an alternative to the problem of over-relying on technological experts as a means to understand technology. This chapter approaches an arguably similar situation yet argues for the opposite methodological conclusion: to radically distrust actors’ framings for who counts as part of the relevant story and in what ways. Instead, given the epistemic and ethical boundary-work summarized in Ted’s concept of “the box,” a more appropriate methodology would be for the researcher to (i) expect that frames (i.e., experiential limits to what should be known and cared about at work) will result from institutional, not personal, creativity; and to (ii) identify, using the researcher's own discretion, historical circumstances giving rise to what is outside the edges of participant awareness. This dissertation's analytical approach therefore departs from that of *Aramis* (Latour 1996) because it interrogates Latour's assumptions, namely that engineering project employees possess the authority and awareness to narrate their technology's sociopolitical embeddedness descriptively and predictively. Rather than assuming that as a given or point of departure, this chapter has instead taken the *awareness* and *authority* of "engineering research" project staff as an historical outcome to be explained.

EPILOGUE: ENGINEERING ETHICS AS AN INDUSTRIAL STABILIZER

Normative Holism as an Element of Carbon Engineering Workforce's Sociotechnical Imaginary

> "I mentioned the IEA before. It is an agency 'by subscription.' Does that bias the agency? I don't think it does. But maybe I have been brainwashed, in my career."—CCS expert, 2017

"Burning the Future" has investigated the targets of care and responsibility that carbon engineering industries institutionally cultivate, and carbon engineering professionals circulate, negotiate, and advance in their professional activities. It has not been bounded by one presumed object or one political project. It is not a complete internalist history of a single technoscientific community, nor an ethnography of a single technology and the many worlds it aligns (Star and Griesemer 1989), nor a historical epistemology of how one concept evolved. Neither is it organized by the political advocacy for an "energy transition" or indeed an assumption that one is underway, contra High and Smith (2019)'s characterization that "much" current energy research in anthropology assumes that such a transition is in motion and deems this necessary and desirable. Instead it performs the traditional ethnographic work of inventing of a more expansive frame of reference for a social circumstance, and letting fieldwork suggest that changed frame.

The experience of fieldwork conveyed that "personal beliefs" and subjective notions of responsibility held by CCS experts did not seem to be relevant to their practice, because the contours of the problems that many knowledge workers had been hired to address had already been formed before their arrival, and thus would not be able to be changed even if they were misaligned with personal beliefs and definitions. Workers in the carbon storage research industry did not need to have an intensive intellectual and ethical relationship with carbon storage itself, judging by the fact that no matter the mode by which I searched for this relationship, it always appeared as very faint, provisional, and probably called into existence by the fact of my asking. Interlocutors in the CCS research field inhabited roles that they might have assumed at any other workplace: executive assistant; accountant, administrator, secretariat. As subjective concepts of responsibility emerged as less important than institutionalized concepts of it for affecting the shape of how engineering research practice, I instead began to assume that professional modes of responsibility are something that gets performed as a prerequisite to economic participation. Work to keep carbon storage research operating was "work" in the sense that when I asked one person in passing whether they ever discuss carbon storage with friends outside of work, I could be met with a smile and a shake of the head, no: with friends, s/he would instead discuss "human things."

The dissertation has brought together the study of "responsible engineering" (specific to Australia, and in flux with Australia's institutional repositioning of these types of experts) together with an inquiry into the dynamics of one field of engineering research, that of CCS. "Responsible engineering" is the object of this study because the term "ethical" is too easily taken up by actors to refer to contemporary ethics codes [alone], or to specific dangerous or scandalous events. Yet codes and scandals are only two sites of multiple institutional regimentations of "(ir)responsibility," amidst laws, regulations, standards, company policies, and inter-company divisions of labor. By seeing "responsibility" in a more distributed manner, this study has found that the experience of energy and environmental professionals with carbon engineering research is structurally similar to that of many other energy-related businesses. It has explored these similarities through observing elements of the institutional environment in which CCS is responsible engineering. These are: acceptance of epistemic limitation as a precondition for thought (ch. 4), codified ethics that may paradoxically isolate a profession from popular contestations of its work (ch. 3), collective social forgetting of the partial nature of the cleanliness that financially-consequential representations of technoscience depict (ch. 2), and the prevalence of promissory and virtual representations that help maintain productivity amid temporary, contract-based intellectual work (ch. 1). I have argued that as “energy expertise” departed from direct state employment and came to manifest within private companies petitioning the state for legislative and economic support, CCS research engineering has emerged as one such petitioner—and has often succeeded as such.With these elements having been explained, one final conceptual step can help summarize the blurriness that emerges between particular needs (i.e., those of clients hiring knowledge-workers), and generalized social goods (i.e., climate change prevention.) This is the tendency to adopt a common mode of conceptualizing engineering work’s sociopolitical benevolence, named as “normative holism” (Downey 2012) below.

Normative Holism

Even though I never was given any tasks during my internship at the CCS research organization[1], I still thought of new questions to ask each day. I would think of what to ask next while walking or taking the bus to arrive, or I would be inspired by social conversations with Australians who knew my presence in their country was mediated by my interest in their carbon

[1] An example response to my search for internship tasks: “I want to see clarity in how you are communicating before giving you these tasks.” As another: “Have you been authorized to seek internship tasks?” Ultimately, I never did show myself to be capable enough, interested enough, or worthy of enough trust to do something that would serve the CCS research organization. The fact that a mutual exchange of knowledge and skills was not never able to be achieved shapes my decision not to represent more scenes from their workplace in this ethnography.

researcher community. One day I targeted Ricardo, already sitting at his desk as I arrived, with an early morning question:

When in the future does he personally expect that CCS technology will be used?

It is probably already being used.

Invoking the oil and gas companies, who are members or partners of the research organization and recipients of the research, he comments:

"Detecting small movements in a reservoir using seismic? That goes into their black box. There is no way of knowing what they do."

With these remarks, Ricardo conveys that perhaps members of the consortium are already commercializing or using the technologies that his research organization has developed, but he has no way of knowing whether or not this is true.

I am shocked: he seems to have just told me that he has a strong suspicion that petroleum industries are using carbon emissions prevention technologies for oil and gas extraction purposes. To my ear, this sounds like a process of governmental "clean energy" money finding its destination in knowledges meant to intensify petrocapitalism's extractive abilities. But despite my shock, Richardo does not seem troubled.

There is a name for one specific perspective from which no conflict between service to companies and service to society as a whole is visible. By the concept of "normative holism," Gary Downey provides one way to theorize this moral vision endemic to engineering, a highly moralized line of work. He calls normative holism a "dominant image," and defines it as the premise that technological advancement is a social good, and by their work with technologies, engineers provide that good—not only where they work, but also "across the planet" (2012:233). The ability to generate profit with a technology proves that the technology is needed and thereby that it serves a social need[2]. The fact that a technology serves at least one customer is taken to prove that it could possibly serve anyone else at any moment. Indeed, its implicit potential to help any number of additional people means that the act of creating it by definition serves all humankind, hence the term "holism" to refer to humanity as a whole (234). Normative holism is ultimately a vision of engineering as intrinsically a mode of "progressive service": "an ambiguous image of engineering as progressive service that diffused critical inquiry" (Wisnioski 2012:90), as another scholar has described.

The assumptions abetted by holism's image are consequential: such "certainty of progress" that Downey identifies as an experience shared by engineers "across the planet" (2012:2) obviates inquiry into, in a phrase, social and political outcomes. Downey says normative holism "frees engineers from assigning themselves responsibility for the actual consequences of their work" (2012:233). It also frees engineering educators from "responsibility for teaching students how to sort out and assess the diverse effects for different populations of any particular engineering work" (235). "Actual consequences" of projects conducted in the name of technological advancement require no investigation since they have already been imaged in the most favorable possible terms. "Normative holism" elides awareness of unknowns, for example, regarding the distribution of technological benefits. This evokes Kim Fortun's concept of "discursive gaps" which "emerge when there are conditions to deal with for which there is no available idiom, no way of thinking that can grasp what is at hand" and yet "a tendency to rely on established idioms" (2012:452) such as the idiom of "normative holism." Its

[2] Downey does not mention profit directly, but instead emphasizes nationally-specific definitions of "success" that engineers become aligned with. I use the example of profit to demonstrate the interpretive process that Downey identifies: the reading of an observable, specific mode of "success" in the world "back into" the properties of the technological work from which this particular success flowed, which becomes seen as omnibenevolent (i.e., to all persons.)

image of holistic service ultimately creates gaps in people's ability to inquire into the consequences of technological work. It substitutes intention (to create clean energy) from consequence (to intensify extractive practice) and keeps attention placed upon the former, in its potentiality, even when suggestions of the latter emerge, as they did for me when I asked Ricardo about where and when the CCS technology was expected to meet its use.

The findings of this dissertation suggest that the very notion of professional responsibility is itself ideological in its experienced effects: part of a class-specific project of imagining a grander mission for work. I suggest professional ethics may not be "ethics" in the sense that theorists could use the term. Instead, professional ethics would be better conceptualized as a domain in which the political relationships of sociotechnical practice are obscured by imaginaries of responsibility. As Layton explains, "The philosophy of professionalism carried engineers' ambitions beyond technology to politics and policy making generally" (1986:61). In order to persist, this ambition for policymaking needs to be misrecognized by those who hold it. "Professionalism" enables the misrecognition. Although it could be assumed to be a counterweight to irresponsible practice, professional ethics should instead be grasped instead as something that configures the boundary between responsible and irresponsible in such a way that capitalist extraction remains secure. This in turn suggests that investigations of political economies of technological practice are necessary for any serious study of ethics that addresses "technology." Thus, the results of an ethnographic rather than a normative study of "engineering ethics" offers a serious challenge to problematizations such as "technological ethics" or "energy ethics" (High and Smith 2019) because it points out that practitioners' ethical self-understandings are a means of stabilizing rather than contesting technological industries.

I have argued in this work that descriptions of CCS technology productively bridge a series of contested social boundaries in order to attain support: necessary “pragmatism” versus imaginative idealism; the requisites of existing built socio-material forms versus those of future and potential grids; the desirability of “proven” technology versus that of futuristic innovation; and the question of whether fuel type should be used as a conceptual proxy for material, political, and social desirability. With intentionality and sincere investment by workers who hope that serving their workplace aligns with serving a generalized need, CCS technology still fails to emerge “at scale” as a substantive, operative, generalized component of industrial infrastructures. This dissertation has argued that carbon-research-related and other engineering is not a service rendered to “publics” or “societies; it is a service rendered to client-institutions that through normative holism, is imagined as a service to “all.” Put differently, meeting the “needs of the climate,” “Australian needs,” or “the world’s needs” are not areas of intervention for research-adjacent industrial businesses in the ways that meeting the needs of governments or private sponsors of research consortia are. This poses a challenge to Durkheim’s assumption that professional ethics could prevent the dis-integration of an industrial society (1984 [1933], 1992).

Discontinuing the Internship

On the second floor of an office, 10 minutes’ walk from the center of the University and 15 minutes’ walk downhill from downtown, I am feeling the need to discontinue my internship at the carbon capture and storage research organization. A research manager and I have retreated to a small, empty office along the internal wall of the building to discuss this.

“Now I am hearing you say,” here he consults my email on his printed, folded page, “CCS is a bad idea. Can you please explain what you mean by that?

“Can I please go print something out?” I ask.

“No, do it right here.” The manager notes what I say in small capitals in his notebook.

“The purpose of this technology is to reduce emissions, but it is never going to be used at scale—there is not enough political will.”

“CCS needs to go through a process of concept, to putting them together in a low-risk solution,” he replies. “Capture, that’s from the chemical industry. Transport, we already know how to move CO2. Storage, there is already natural gas storage. We could say it is at Technology Readiness Level 1.” I ask if I can record the definition of TRLs, then turn the tape recorder back off, after he has defined a numeric scheme for how technologies could be classified, attributed to NASA.

“There are multiple valleys of death,” he adds. “After In Salah and Weyburn, we hit a bit of a stall. There are a new tranche of projects. We are delivering Boundary Dam, Petra Nova, the Middle East, Regional Partnerships; the European projects are less formed. We are needing economic and political levers, political will.” Naming a local power company, he continues: “They are saying that they are going to move out of coal. The *users* will not adopt CCS because it is not competitive. They are playing a reputational type card. To keep the public happy. There are subsidies for solar, wind, etc. There is nothing in place for a company removing their CO2 emissions, a cost. CCS is cheaper than solar when looking at scale.”

Whereas my comment presented the technology’s undesirability as a flaw that rendered it unable to reduce any emissions, the research manager’s statements bracketed the sociopolitical nonviability of the technology as immaterial to whether it would eventually reduce emissions. His remarks conjured an image in which the intrinsic rationality of using a “scalable” solution would eventually outweigh any resistance. Social nonviability would be a problem of the *social*, not a problem of the technology. He presents a lack, a gap: a portrait of a lonely company with good intentions and no support. This is a hopefulness of a someday-future-more-rational public, as well as an implicit wish that I'd not abandon the internship and stay with that hopefulness myself.

I tell him that a youth climate NGO also headquartered nearby is talking about "climate justice" as a goal—"Who knows what they mean by that," I say, in a nod to what I believe he may think, about the lack of clarity in goals as a core problem for would-be interventions.

"If you want to talk to them, the Youth Climate, you will hear about social challenges and not much else. The louder voice, versus a balanced view," he retorts.

I tell him that the business model of his company does not actually include any emissions reduction. The company could continue conducting business as usual, *ad infinitum,* with no climate effects.

He answers with a discussion of the nature of the company:

"[This] is a member-based organization. We do R&D for members' needs. We can actually bring it to here, to bring technologies to this place." He points to a graph.

"We don't operate commercial-scale projects. If the funders are failing," like the coal company named earlier, whom he re-names, "we are looking at how to be masters of our own destiny in that regard. Our technologies moving up to being commercial-scale projects. Our technologies—pressure tomography, in Stage 3; developing technologies with" an oil operator; if the oil companies "don't want to do that project, we are not advocates. But we are showing that it works. The company is not against the ideas of being operators of a CCS project ourselves. We have a good reputation. To deliver at level 10. Hopefully, we'd have the confidence of investors. The confidence of governments. Political parties, to support the things."

After a pause, he asks me, “How do you plan to write this at the end? If it were a technical one, it would be Challenges, Solutions, Recommendations.” I struggle to answer aloud, and his phone lights up with his wife’s name, calling. He asks, “How do you want to use me in this? A deeper discussion, or as a member of CO2CRC?” He has a blank face. I don’t know how to answer because I did not understand their differentiability. I still do not. Returning the focus to my writing process, to *me,* he tells me, “You will be expert in this. You need a clear plan on this.”

“Any day of the week,” I was welcome to come in. The fact that my vision for my PhD had changed was not a problem for him, which he in fact expected; his own vision had evolved during his PhD.

“What you said are not technical arguments against CCS. The scale-up is a big challenge.”

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